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DEVELOPMENT DIGEST

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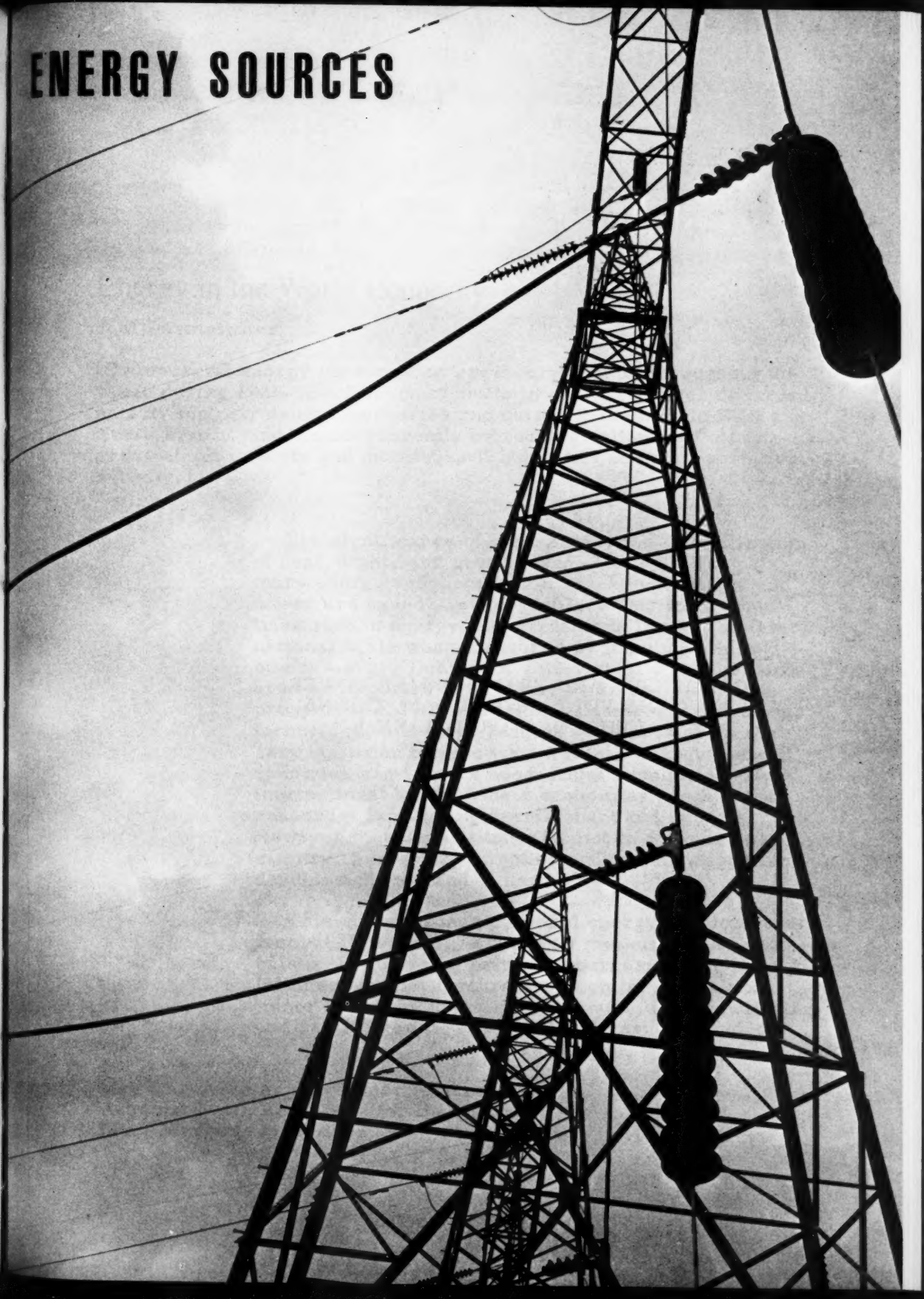

CONDENSER AND TRANSFORMER TOWERS
AT THE VOLTA RIVER DAM, GHANA.
[PHOTO: WORLD BANK.]

Energy in the World Economy

Joel Darmstadter

[Commercial energy consumption grew very rapidly throughout the world during 1925-68. Important shifts in energy sources occurred, notably the petroleum discoveries and output in the Middle East and North Africa, and the concurrently increasing reliance of many areas on oil imports and on oil-based industrial and transportation activity.]

The significance of the contribution to civilization of heat, light, and power—and, hence, of the primary energy resources upon which heat, light, and power are based—is undeniable. Yet, many countries rich in energy resources rank low on the international scale when measured by income; while others—e.g., Denmark, with virtually total dependence on imported fuels—may be among the most prosperous. For energy-rich countries, education, technology, and other natural resources are a necessary condition for growth; whereas energy-deficit countries can acquire needed fuel supplies through international trade if their economies possess the resources facilitating development and exports. However these conditions are met in a particular country, energy consumption and overall economic development go hand in hand.

This study focuses on world energy developments from 1925 to 1968. Energy as measured here comprises the following primary sources: solid fuels (bituminous coal, anthracite, lignite, and certain minor fuels, including peat); liquid fuels (crude oil and natural gas liquids); natural gas; and hydro-

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electricity. Nuclear energy was insignificant during most of the period under review. Coverage is limited to "commercial" energy sources—so-called because of their dominance in domestic and foreign energy trade and their near-indispensability in modern industrial activity. Such non-commercial energy sources as fuelwood, organic wastes, wind, waterpower (other than for electricity), and the energy of draft animals and human beings are excluded. Some of these non-commercial energy forms remain important in many of the less developed countries, but only fragmentary and incomplete data are available concerning them and the consequence of their omission is to some extent minimized by the very low efficiency with which such fuels are traditionally used. The various energy sources are made statistically comparable and additive by converting them to common units based on their respective calorific values. Coal is used as the energy common denominator because of widespread international practice rooted in the earlier preeminence of coal. (One metric ton of crude oil contains, on the average, about 1.5 times the British thermal units (BTUs) contained in a metric ton of coal. For the hydroelectric component, we follow United Nations practice and calculate the coal equivalent of hydroelectricity at the inherent heat value of the electricity generated—i.e., 1,000 kwh equals 0.125 metric tons of coal equivalent.)

Trends in Total Energy Consumption

Worldwide energy consumption increased from somewhat under 1.5 billion coal equivalent tons in 1925 to nearly 5.5 billion tons in 1965, a yearly growth rate of around 3.3 percent (Table 1). In the postwar period (1950-65) growth in total world energy consumption proceeded at the accelerated pace of around 5 percent yearly. Between 1965 and 1968, when worldwide energy consumption reached an estimated level of 6.3 billion tons, this rapid rate of expansion decelerated somewhat, influenced by developments in Mainland China (the internal unrest spurred by the Cultural Revolution) and by slower growth in Eastern Europe. The one exception to generally faster growth in energy consumption during the post-World War II years was the Soviet Union, whose post-1950 growth of around 7.4 percent per year compares with a 1925-50 rate of 10.4 percent. Nevertheless, the Soviet growth rate has persistently exceeded the growth rate for the world as a whole, and its share of worldwide energy consumption has risen steadily from 1.7 percent in 1925 to around 16 percent in 1968. For the Communist group of nations as a whole the increase was from 7 percent in 1925 to 29 percent in recent years.

Rising shares also occurred in Latin America, Africa, and Asia. The postwar rise of Asia reflects in part the phenomenal momentum of energy growth in Japan, whose annual postwar growth rates of 10 to 15 percent have been virtually sustained to the present time.

Table 1: World Energy Consumption, by Regions

	Energy Consumption (millions of metric tons)[a/]				Average Annual Growth Rates (Percentages)			Per Capita Energy Consumption in 1968 (Kilograms)[a/]
	1925	1950	1965	1968	1925-50	1950-65	1965-68	
North America	749	1,276	2,040	2,359	2.2	3.2	5.1	10,629
Western Europe	517	584	1,117	1,242	1.0	4.4	3.6	3,543
Oceania	16	29	61	72	2.6	5.0	5.6	3,937
USSR	25	303	881	1,025	10.4	7.4	5.2	4,309
Eastern Europe	55	161	375	408	4.4	5.8	2.7	3,920
Communist Asia	24	43	323	332	2.4	14.4	0.9	434
Japan	31	46	189	280	1.6	9.9	14.1	2,770
Other Asia	30	60	197	242	2.8	8.2	6.7	224
Latin America	25	66	200	245	4.0	7.6	6.9	916
Africa	14	42	93	102	4.5	5.4	3.6	303
WORLD	1,485	2,611	5,475	6,306	2.3	5.1	4.8	1,810

a/ All figures based on coal equivalents.

SOURCE: Derived from detailed country tabulations; this is true of all tables presented here.

There was a decline in the relative positions of North America and Western Europe from 1925 to 1968 from approximately 50 to 37 percent and from 35 to 20 percent respectively.

These increases in energy use have greatly exceeded the growth of population in every region. Despite some shifts in relative shares, the regional gaps in per capita energy use remain strikingly wide. In 1968, North America's per capita energy consumption was nearly 2.5 times larger than that of the Soviet Union, which in turn had a per capita level roughly 10 percent above that in Eastern Europe or Oceania and 20 percent above that in Western Europe. The most extreme disparity is reflected in the fact that North American per capita consumption was forty to fifty times the levels prevailing in Africa and the developing parts of Asia.

Interfuel Shifts in Energy Consumption

The size and growth of total energy use is affected by the changing role of the different fuels. The early preeminence of the British iron and steel industry—indeed, the character of the Industrial Revolution as a whole—was closely tied to coal. Early industry in the United States was tied to the location of falling water as a direct source of mechanical energy. Subsequently the development and distribution of electricity as a commercial energy form revolutionized the organization of the factory system. And who would deny the pervasive influence of the Automotive Age and the fact that its emergence has proceeded hand in hand with the growth of the world petro-

leum industry? Looking to the future, atomic fission (and perhaps fusion) may well turn out to be the most profound and enduring scientific development in energy during the second half of the 20th century. By 2000, nuclear energy in a variety of applications (not just as a source of electricity) could take its place as an essential element in new levels and forms of economic activity.

To date, the major transformation in commercial energy sources in the 20th century is the marked long-term decline of solid fuels concurrent with the rising importance of oil and natural gas. In 1925 coal's 83 percent share of energy consumption had already slipped from its 95 percent level at the turn of the century, but this fuel was still preeminent among the four primary commercial energy categories—coal, oil, gas, and hydro—surveyed here. During the next four decades, coal's share dropped steadily until by 1968 it was only 37 percent of world energy consumption; the greatest slippage took place after World War II. In absolute terms, worldwide solid fuel use did increase—by over one billion tons between 1925 and 1968; even so, this increase was not markedly greater than worldwide population growth. Each of the other energy sources—liquid fuels, natural gas, and hydroelectricity—has significantly and progressively raised its share of worldwide energy consumption. By 1968 liquid fuels were leading among the energy sources, with a share of 43 percent of world energy consumption compared to 13 percent in 1925. Natural gas consumption went up even more rapidly; its long-term annual growth rate of somewhat over 7.5 percent per year compared

Table 2: World Consumption by Energy Source and Region

	Solid Fuels		Liquid Fuels		Natural Gas		Hydro-Electricity	
	1925	1968	1925	1968	1925	1968	1925	1968
World Consumption (million metric tons of coal equivalent)								
	1,230	2,315	197	2,702	48	1,157	10	132
Percentages of World Energy Consumption in given year (%)								
	82.9	36.7	13.3	42.8	3.2	18.3	0.7	2.1
Percentages of Total Energy Consumption in each Region (%)								
North America	74.5	21.9	18.9	43.6	6.0	32.6	0.6	1.9
Western Europe	96.0	37.3	3.2	54.3	---	4.7	0.7	3.5
Oceania	92.6	48.6	6.9	48.6	---	---	0.5	2.8
USSR	64.9	43.1	34.2	33.0	0.7	22.6	0.1	1.3
East Europe	91.2	78.2	6.5	15.2	2.2	6.4	0.1	0.2
Communist Asia	94.0	91.9	6.0	7.2	---	---	---	0.9
Japan	92.4	27.9	4.4	67.1	0.1	1.4	3.1	3.6
Other Asia	73.7	33.5	24.6	56.2	1.5	8.3	0.2	2.1
Latin America	37.6	6.5	56.6	70.6	4.2	19.2	1.6	3.7
Africa	91.6	54.9	8.3	41.2	---	2.0	0.1	2.0

with slightly over 6 percent for liquid fuels, had accounted for a mere 3 percent of world energy consumption in 1925, but by 1968 its share had risen to 18 percent. Hydro consumption rose as fast as oil over the long run, but its 2 percent share of world energy use in 1968 makes it a minor factor in a global context. Virtually every part of the world has reduced the proportion of solids in its energy balance, while increasing the share of liquids, natural gas, and hydropower.

In oil, drastic long-term changes were recorded by Western Europe (up from 3 percent of total energy consumption in 1925 to 54 percent in 1968) and Japan (up from 4 to 67 percent). The rising contribution of liquid fuels to North American energy consumption (up from somewhat under 20 percent in 1925 to a bit short of 45 percent in 1968) was, in relative terms, not quite as dramatic (the oil industry, after all, developed quite early here), though it was very large in an absolute sense since oil consumption increased more than four fold and represents nearly half the world's consumption. In natural gas, only three areas were drawing on this fuel for significant portions of their total energy requirements by 1968: these were North America, where use of gas in total energy went up from 6 percent in 1925 to over 30 percent in 1968; the USSR with an increase from under 1 percent to 23 percent (with an average annual long-term growth rate of nearly 20 percent); and Latin America (from 4 to 20 percent). Together, the United States and the USSR in recent years accounted for over 80 percent of the world's natural gas consumption, though these proportions are likely to gradually change in the wake of production stemming from Dutch and North Sea discoveries. The hydroelectric portion of energy consumption remains relatively insignificant except in particular countries: for example, for Norway the 1965 share was 44 percent; for Switzerland, 18 percent; Sweden and New Zealand, 16 percent; and Canada, 9 percent. In recent years, the hydroelectric shares of total energy consumption have tended to rise noticeably in the less developed regions of the world, while in the most industrialized areas they have become more or less stable since available waterpower sites are already substantially exploited.

In the 1920s choices as to alternative fuel sources were severely circumscribed, coal being the only widely available energy resource around which most energy-using activies and industries were organized. Over the years the discoveries of reserves of other fuels, and associated developments in transporting them, have widened the choice of fuels available to satisfy the requirements of different areas. Of course, these changes have also resulted from, and been influenced by, the rapid growth of economic activities essentially captive to a given fuel (e.g., automotive transport), and from the substitution of other energy sources for coal in its traditional mar-

kets such as railroad transportation and residences. Supporting coal's position in the 1920s was the continued use of the steam locomotive; coal-burning steamships were still common. Coal was the preponderand fuel in thermal electricity generation, and it had a virtually complete grip on house heating. Each of these conditions favorable to coal has eroded substantially in the following four decades. A clear manifestation of these changes was the disproportionately fast growth of economic activities, industries, and technological processes oriented to the use of the emergent energy forms. Automotive transport, railroad dieselization, oil and natural gas heating, petrochemicals, are examples. Fundamental to the shifts in primary energy consumption were the more advantageous physical properties of oil and gas (compared with solid fuels) and the impact on changing relative fuel prices of major discoveries of oil and gas and of the development of the necessary transportation techniques and facilities.

Supplies. World crude oil supplies were being boosted by major new supply sources. Six of the world's ten leading oil-producing countries in 1968 had virtually no recorded output in 1925. Many of the bigger Middle Eastern oil discoveries date only from the late 1930s or beyond and those in the North African fields were still more recent. Although a few countries (principally the United States, Venezuela, and the Soviet Union) were prominent in world oil production in the early years, it was only with the pervasive impact of oil supplies surging from the newer oil fields after World War II that established fuel use patterns began their widespread change. With respect to natural gas, enormous expansion of output took place in North America and in the USSR, much of it occurring after World War II. Western Europe's onshore and offshore natural gas production got started only during the late 1960s.

This growing abundance of oil and natural gas presented energy users with fuels having a number of highly desirable properties. A ton of oil combined the dual virtue of possessing less volume than a ton of coal while yielding 50 percent more energy, so the ton-mile cost of moving energy in the form of oil tended in general to fall substantially below that of coal. As a liquid it could be conveniently handled in loading, unloading, and storage; it was far less subject to damage in transit than coal. It burned more cleanly and in a more controllable fashion than coal; and in numerous applications its thermal efficiency was higher. Many of the desirable features of oil held as well, and sometimes better, for natural gas: cleanliness, ease of use, and—when compared with manufactured gas, which it began to replace—high calorific value relative to volume; with fewer polluting features than coal or oil, it promises to offer newly valued advantages.

Transport. The rapid extension of oil and gas pipeline networks with progressively larger diameters, and the ever-increasing size of

tankers culminating in recent years in the arrival of the super-tanker of several hundred thousand deadweight capacity, are parts of the energy story. Some illustrative statistics, reflecting transport costs in the 1950s in the United States and Canada, are as follows (values in U.S. cents per metric ton of coal equivalent per 100 miles): oil by tanker—5.6; oil by pipeline—11.2; coal by collier (coal ship)—27.5; coal by rail— 75.0; gas by pipeline—34.4. These alternative costs relate to volumes and distances which tend to depict each category in an optimum light—for example, coal by rail and oil by large tanker relate to distances of 1,500 to 2,000 miles, which are cheaper per ton-mile than for shorter distances. However, short hauls have little effect on the international aspects of energy transport. The overland cost of transport for coal is the highest per ton-mile, and this disadvantage has grown as the pipeline costs for oil and gas have decreased markedly from their prewar relative levels. The relative ocean costs have shifted less; nevertheless, the pre- and post-World War II disparity between ocean-transport costs for oil and coal has remained wide—perhaps has even widened.

In recent years significant developments have been taking place in the field of energy transport. With transport costs a significant proportion of the price of delivered energy, these developments will continue to influence the relative price position of the different energy sources. In coal, for example, the development of the "unit train," shuttling exclusively and on a prescribed schedule between a fixed coal mine and fixed terminal point (generally an electric utility), has tended to improve the competitiveness for coal, especially in thermal electric generation, by lowering rolling stock idling time and spreading fixed costs over more ton-miles. Another notable development is the growing size of ocean vessels. In the international coal trade, a continuing trend toward larger-sized, lower unit-cost bulk cargo vessels has lowered the cost of ocean transport during the last decade and contributed to the competitive advantage of U.S. coal in foreign markets. More dramatic is the emergence in world oil movements of super-tankers. Around the mid-1950s the world's fleet averaged about 16,000 dwt per tanker; about a decade later, the average in service had risen to 29,000 dwt, and those on order averaged 60,000 dwt and ranged up to well over 200,000 dwt. With scale economies in construction costs, increasing size of ships has meant falling capital costs per unit of oil carried.

Trends in Production, Consumption and Trade

The declining world role of coal and the growing importance of petroleum has been accompanied by dramatic changes in the geographic distribution of world energy output and in regional energy supply-demand balances. Regional shares of world output have

shifted markedly away from the advanced parts of the non-Communist world to the newer oil-producing regions in the Middle East and Africa. North America, Western Europe, Oceania, and Japan accounted for nearly 90 percent of world energy production in 1925; by 1967 their share had dropped by about one half to 45 percent, a decline largely associated with the stagnation of coal mining in these regions (see Table 3). The counterpart to these declining shares consisted of two major developments: first, the sharp increase of the Communist part of the world, up from 7 percent of world energy production in 1925 to 28 percent in 1967. Spearheaded by the growing energy-producing capability of the Soviet Union, the Communist area's growing world share applies to energy production in the aggregate as well as to each individual primary energy commodity. The second major factor was the vast expansion of output in the oil-rich countries of the Middle East and, to a lesser extent, North Africa. Accounting for one half of one percent of world energy output in 1925, the percentage for the combined areas had risen to 16 percent of a vastly larger total by 1967.

It is striking how, in 1925, virtually all the major energy-consuming regions of the world accounted for similar shares of world consumption and production—i.e., how each of these regions met practically all its energy needs from indigenous supplies. North America consumed approximately one half the world energy total and produced a like share. For Western Europe, the world share of consumption or production was a bit over one third; for the combined group of present-day Communist countries, around 7 percent. Except for Latin America and the then insignificant Middle East production—the 1925 share of world output of both regions substantially exceeded their percentage of world consumption—this pattern of roughly similar portions of world energy consumption and production prevailed for other areas. Of course, this tendency toward equality between <u>total</u> fuel output and consumption did not apply to liquid fuels (except in the case of the U.S. and the USSR) but it did apply to coal, which exerted a decisive weight on the world energy total and most of the regional energy totals.

Four decades later, regional self-sufficiency persisted only in the Communist group, where it was at least partly a consequence of autarkic policies. Elsewhere, marked regional imbalances had appeared—notably in Western Europe which imported 54 percent of the 1967 energy it consumed. The Far East has evolved into another energy-deficit region, and Japan, in particular, experienced a drastic long-term change in its energy position. The country's ratio of production to consumption was 1.1 in 1925, and by 1967 it was down to under 0.25. The North American position in 1967 (34 percent of world energy production, 38 percent of consumption) reflected, by comparison, only a modest deficit status. Other deficit regions were non-Caribbean Latin America and Oceania. The former had been per-

Table 3: World Energy Production and Regional Balances 1925 - 67

	Production (million metric ton coal equivalent)		Percentages of World Production		Ratio of Production to Consumption[a/]	
	1925	1967	1925	1967	1925	1967
North America	779	2,114	49.7	34.4	1.04	0.95
Western Europe	532	540	34.0	8.8	1.03	0.46
Oceania	16	46	1.0	0.7	1.03	0.69
USSR	27	1,124	1.7	18.3	1.07	1.14
East Europe	65	365	4.2	5.9	1.18	0.94
Communist Asia	23	255	1.4	4.1	0.95	1.00
Middle East	8	764	0.5	12.4	3.32	11.24
Japan	33	61	2.1	1.0	1.08	0.24
Other Asia	31	141	1.9	2.3	1.11	0.92
Caribbean	34	383	2.2	6.2	2.98	3.04
Other Latin America	6	68	0.4	1.1	0.45	0.69
North Africa	0.3	200	---	3.3	0.10	10.00
Other Africa	13	84	0.8	0.1	1.22	1.09
WORLD	1,567	6,143	100.0	100.0	1.06[b/]	1.04[b/]

a/ These ratios of production to consumption indicate whether a region has an export or import balance in energy, and by what proportion. North America, for example, exported 4 percent of its production of all types of energy in 1925, but by 1967 it had shifted to importing, on balance, 5 percent of what it consumed. (These regional balance figures are not equivalent to total international trade since some trade is among countries of the same region.)

b/ World consumption figures are less than production because bunkers (fuel for ships) are excluded from national consumption data, and for unexplained discrepancies.

sistently deficient in energy supplies throughout the period under review; but the latter may in a few years revert to surplus status or at least a balanced situation, given Australia's rising oil and gas discoveries and its expanding coal exports.

The energy-surplus areas in 1967 are mainly the oil producing countries in less developed regions. Although U.S. oil production has risen persistently over the years—from 160 million tons in 1925 to over 500 million tons in 1968—the nation's share of world oil production declined steadily from 70 to 25 percent. At the same time, the Soviet share rose from 5 to 15 percent. The most interesting story concerns the new oil-producing countries; eight of the fourteen leading world producers in 1968 recorded virtually no output in 1925—

Saudi Arabia, Libya, Kuwait, Iraq, Canada, Algeria, Abu Dhabi, and the Kuwait Neutral Zone—but they accounted for over 30 percent of the world's oil production in 1968. In the Middle East there had been only two oil discoveries prior to 1925—in Iran in 1908 and in Iraq in 1923; and the latter did not lead to consequential production for some years. Three Arab states which accounted for over 20 percent of the world oil output in 1968 began producing their first recorded crude oil in the comparatively recent years of 1936 (Saudi Arabia), 1946 (Kuwait), and 1961 (Libya). With Canada starting to develop her major oil fields only in the late 1940s, and the Soviet Union doubling its already considerable level of output within the five-year period 1955-60, it has really been principally since World War II that the world oil industry has grown to its present enormous size. One might finally take note of a few other countries which have receded in their world ranking. The most conspicuous is Mexico whose 1925 world share of 12 percent was second only to the United States. Its subsequent decline to scarcely 1 percent in 1968 has been roughly compensated by the long-term rise of Venezuela, although—under the impact of Western Europe's shift in reliance to cheaper crude oil from the Middle East and Africa, as well as U.S. import quotas—Venezuela's world share has been declining in recent years. Indonesia's share has tended to fall over the years, but there are prospects for relatively substantial growth in output in the years ahead.

International trade. The trends summarized here were accompanied by vast increases in world energy trade. In 1925 about 14 percent of the primary energy consumed had crossed foreign borders; by 1968 the proportion was up to 33 percent. For the interval for which comparable data exist, 1929-65, world energy consumption increased at the average annual rate of 3.2 percent, world energy trade volume rose by 4.8 percent a year, while interregional trade among the principal areas of the world went up by over 6 percent yearly. (Energy's share in the total value of world trade was somewhat over 6 percent in 1929; by 1967 it had risen to approximately 10 percent, being valued at about $21 billion.) The dominant force in the expansion of world energy trade has clearly been liquid fuels; comprising under one third of world energy exports in 1925, they rose steadily, reaching 90 percent in 1968. As to the commodity composition of the trade in liquid fuels, the dominant component in the 1920s comprised refined petroleum products (gasoline, kerosene, fuel oils, and lubricants), which accounted for around 55 percent of the world liquid fuels trade, while crude oil represented 45 percent of the total. Over the years, crude oil moved to the forefront, and in recent years accounted for around three quarters of the total, refined products slipping to one fourth. By definition, this shift from products to crude oil reflected the growth of refining capacity in major consuming areas, such as Western Europe and Japan.

As liquid fuels rose to dominance in world energy trade, solid fuels fell from two thirds of the world total in 1925 to 8 percent in 1968. In absolute terms, however, there was little long-term change in the tonnage of coal traded. Gas and electricity, largely limited to natural gas and electricity exchanges between Canada and the United States, and electricity sales within Western Europe, have accounted for only trivial shares of international energy trade. Movements of pipeline gas within Europe, and slowly rising ocean transport of liquefied natural gas, seem likely to alter that situation in years to come.

We have seen how the long-term shift from coal to petroleum was accompanied by a growing geographical imbalance between the location of energy supply sources and the central areas of energy demand. In looking at the directional pattern of world energy flows that has emerged in fulfilling this web of interdependence, it is well to keep in mind the geopolitical issues bearing on this characteristic of the world energy economy. For it has produced for numerous fuel-deficient regions and countries a sense of anxiety about the reliability and adequacy—under various circumstances—of their sources of energy supplies; while for major producing areas, such as the Middle East, North Africa, and the Caribbean, the assurances of stable and growing markets are a critical element in their aspirations for economic development, In view of recurrent political crises in the Middle East as well as an almost chronic uncertainty over contractual relationships between host-country governments and the concessionary international oil companies, such considerations have assumed heightened importance in recent years.

The most significant of these interdependencies that have grown up is that of Western Europe and the Arab countries (along with Iran). In the mid-1960s, Western Europe's imports of Middle Eastern and African oil contributed 40 percent of world energy flows and three fourths of Western Europe's energy imports—and also represented the dominant shares of the exporting area's oil shipments. The Middle East has figured significantly in West European energy imports for the greater part of the post-World War II period; the rapidly expanding role of North Africa, and particularly Libya, dates only from the past decade. Note also the Far East's (chiefly Japan's) paramount reliance on the Middle East relative to total energy imports, with a 1965 figure of well over 80 percent.

A few other changes between 1929 and 1965 in world energy movements may be noted. The relative importance of the present-day Communist area's coal shipments to Western Europe (chiefly from Poland) declined sharply—whether measured by proportion of world energy trade, by a share of the Communist area's energy exports, or by a share of Western Europe's energy imports. However, by the

same criteria, Communist (essentially Soviet) oil shipments to Western Europe have remained of some considerable significance. The Caribbean area's oil exports to the United States represented 16 percent of world energy flows in 1929, and 11 percent in 1965, and they continue to comprise preponderant shares of both Caribbean energy exports and U.S. energy imports. Among regional energy exchanges that have disappeared as a factor of importance in trade are West European coal shipments to Latin America, Africa, and today's Communist Europe (nearly 15 percent of world energy movements in 1929). Similarly, the United States had been a notable oil exporter in 1929, but by 1965 U.S. oil exports had essentially disappeared from the world scene.

A particularly striking statistic is energy's continuously rising share of the value of total exports of underdeveloped countries to developed regions of the world. From 15 percent in 1950, this figure has risen steadily, reaching over one third in 1967. The absolute value of energy flows from underdeveloped to developed areas in 1967—virtually all petroleum—is estimated at $10 billion, one half of it originating in the Middle East. The figures suggest the need for caution in dealing aggregatively with the export potential of the underdeveloped countries as a group, because so large a portion of that potential reflects only a single commodity originating in only limited parts of the world.

Energy Consumption and Gross National Product (GNP)

A prominent characteristic of per capita consumption of commercial energy forms is its systematic and close association with indicators of general economic development, measured by per capita GNP. This relationship between GNP and energy holds both cross-sectionally and historically: the higher a nation's income or output on the current international scale, the higher, in general, its level of energy consumption; as its GNP rises over time, so does its energy consumption—in close, even if not proportionate, conformity. Some amount of electric generating capacity is obviously required in order to support a modern industrialized economy, or one on the move toward it. This input of energy may take the form of an increase in motorized capital equipment, endowing each worker with more horsepower with which to increase his productivity. Conversely, advancing living standards involve new wants the fulfillment of which is made possible by fuels and power, e.g., the private passenger car, heat and air conditioning, numerous household appliances, and air travel.

When national energy consumption and GNP (both per capita) are plotted against each other, the resulting scatter of points falls within a fairly narrow band along an upward-sloping regression line. The

close association is reflected in a correlation coefficient of 0.87. Of the twenty top-ranking nations in terms of per capita GNP, fifteen are also among the top twenty in terms of energy consumption per capita; of the ten lowest in GNP per capita, eight are among the ten lowest in energy consumption. There are nonetheless sufficient exceptions (and a few outright anomalies) to warrant a somewhat closer look at the energy consumption per unit of gross national product (i.e., per $1 of GNP in Table 4). In general, the energy-GNP ratio is likely to be lower in predominantly agricultural economies. Among industrial countries, the energy per unit of national output tends to be high where a country's industry "mix" is heavily characterized by activities with relatively large energy requirements such as metallurgy or

Table 4: Per Capita Energy, GNP and Ratios in Selected Countries, 1965

Countries	GNP Per Capita	Energy Consumption (in kilograms of coal equivalent)	
	($)	Per Capita	Per $ of GNP
United States	3,515	9,671	2.75
Canada	2,658	8,077	3.04
Denmark	2,333	4,149	1.78
West Germany	2,195	4,625	2.11
France	2,104	3,309	1.57
United Kingdom	1,992	5,307	2.66
Australia	1,910	4,697	2.46
Czechoslovakia	1,561	5,870	3.76
Italy	1,254	1,940	1.55
Japan	1,222	1,926	1.58
Poland	980	3,552	3.62
Venezuela	882	3,246	3.68
Yugoslavia	743	1,217	1.65
Argentina	718	1,471	2.05
Trinidad & Tobago	646	3,505	5.43
Libya	542	613	1.13
South Africa	535	2,761	5.16
Chile	497	1,119	2.25
Mexico	475	1,104	2.33
Lebanon	438	770	1.76
Peru	367	577	1.57
Malaysia-Singapore	332	424	1.28
Guatemala	318	188	0.59

mining (e.g., Canada, Belgium-Luxembourg, Norway, South Africa, United Kingdom), chemicals (East Germany), or petroleum refining (Venezuela, Trinidad and Tobago). Thus, compared with a country like Denmark, Canada consumes a far greater quantity of energy per capita than could be explained by the relatively slight per capita income differences. This is because Canada—partly as a result of low-cost hydroelectric power—has an energy-intensive industry mix oriented to such activities as metallurgy, electro-process industries, chemicals, pulp and paper, and mining. These differences in industry mix tend to produce larger differences in the energy-GNP ratio than do the different overall levels of industrial development, after a limited industrialization has begun. In the Communist countries, a general commitment toward heavy industry and electrification, and post-World War II reconstruction—reinforced in some areas by thermally inefficient energy use—contribute to unusually high energy GNP ratios.

[Excerpted from Energy in the World Economy: A Statistical Review of Trends in Output, Trade, and Consumption Since 1925, Joel Darmstadter, with Perry D. Teitelbaum and Jaroslav G. Polach. Baltimore (Md): The Johns Hopkins Press, published for Resources for the Future, Inc., 1971, pp. 3, 9-18, 20-26, 28-38, and 40-44.

Geothermal Power

Joseph Barnea

[Geothermal power, based on steam and hot water rising in the earth's crust, has been used in various ways on a small scale and holds promise of much greater use. Chiefly needed is systematic exploration of its underground availability, which could be far larger than is generally thought.]

An old source of power has begun to attract new interest: natural underground reservoirs of steam and hot water are now being tapped on a significant scale. The harnessing of this geothermal energy has already reached an aggregate capacity of a million kilowatts in plants around the world and at the present rate of development it is likely that by the end of this decade the production of electric power from steam fields will be quadrupled. The heat of geothermal reservoirs in many cases comes from a large body of molten rock that has been pushed up into the earth's crust from great depths by geologic forces. This dome of magma heats the rocks in the crust near the surface, which in turn heats the water in fissured or porous rocks to a temperature of perhaps 500 degrees Fahrenheit. Being at depths of as much as six miles, the water is under high pressure and is therefore liquid. Where the hot water can escape through a fissure it begins to boil, and part of it flashes off as steam. The geothermal energy can be tapped by a well driven into the fissure or down to the porous layer.

Hot springs have been known and used since ancient times for medical and recreational purposes in Europe and the Far East. In 1904 the first electricity

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plant powered by geothermal energy was built in the Larderello steam field in Italy, and small projects using natural steam or hot water for power or heating have appeared since then in various countries. Progress was generally slow, and information and expertise rather limited; but in recent years, interest has been accelerating.

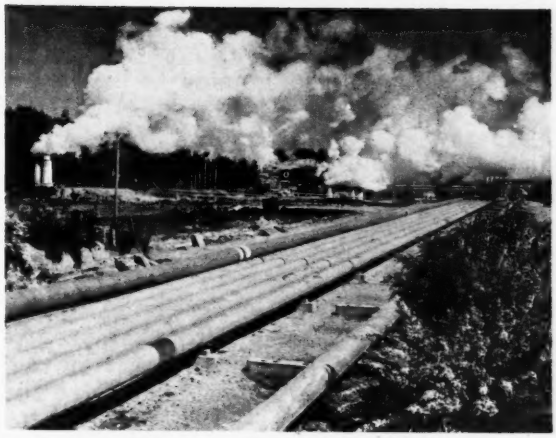
Types of Geothermal Energy

The sources of usable geothermal energy fall into three classes: dry steam fields, wet steam fields and fields of lesser heat content consisting of water at temperatures below the boiling point (at atmospheric pressure). Each type has its special uses and also capabilities for a variety of applications.

The dry steam fields are filled mainly with steam itself, under pressure and at relatively high temperatures, usable directly for the production of electric power. It can be piped right to the turbine, which simplifies the requirements for plant equipment; the investment in plant may be as low as $100 per kilowatt. To minimize piping costs the plant must be located close to the steam wells; moreover, since the steam emerges from the field at low pressure and large amounts of steam must be handled, the effective size of the turbines is limited. This means that the plant cannot be very large: the upper limit at present is about 55 megawatts. Power generators of this magnitude, each fed by 10 to 15 steam wells, are now being installed at the Geysers field in California. In locations near the ocean or a saltwater lake the steam could be employed as a heating medium in distillation plants for producing potable water by subatmospheric boiling, the steam in this case being provided without any cost for fuel. So far the existence of five important dry steam fields has been established: the Larderello field in Italy, the Geysers field in California, the Valle Caldera field in New Mexico and two fields in Japan. In the absence of systematic exploration it is not yet possible to estimate how many other such fields may lie hidden in the earth's crust.

On the basis of discoveries made to date, it seems that wet steam fields may be 20 times more abundant than dry steam fields. The wet field is filled with hot water (above its boiling point at atmospheric pressure) that does not become steam until the pressure is released by drilling into the field. The superheated water, typically at temperatures from 180 to 370 degrees Celsius (350 to 700 degrees Fahrenheit), flashes into a mixture of steam and water as it comes to the surface. About 10 to 20 percent of the discharge, by weight, is steam; the rest is hot water. The steam can be used for power production; the hot water has a multitude of potential uses. At the Wairakei wet steam field in New Zealand, for example, the steam fraction is fed to a power-generating plant and the hot water is dis-

carded into a river. In this respect geothermal energy has paralleled the history of the discovery of petroleum, which at first was used only for kerosene lamps. Now geothermal development is entering a more sophisticated stage through the analysis of its components and their combination into multipurpose projects.



Wet steam field, Wairakei, New Zealand. [Photo: Embassy of New Zealand.]

There are already installations in which the steam of a wet steam field is used for power production and some of the hot geothermal water is distilled, without the addition of any more heat, to make fresh water. (Distillation is possible because the pressure in the flash-distillation plant is kept below atmospheric pressure by exhaust pumps.) A further step is planned at a wet steam field recently discovered at El Tatio in Chile. There the Chilean government in cooperation with the United Nations is investigating the development of a facility that will generate three products: the steam will first be used to produce electricity; hot water produced from the steam will go through a desalination plant, producing fresh water; and the effluent from the hot-water feed will be concentrated in a mineral-rich brine from which valuable minerals will be extracted in evaporation ponds. Following the accidental discovery of mineral-rich geothermal brines in southern California and in the Red Sea, the UN began a systematic search for mineral brines. Two discoveries of potential economic importance have been made so far, one in Ethiopia and one in Chile.

At Kawerau in New Zealand a paper company is using the hot water from a wet steam field for heating in industrial processes. In Iceland the hot water from such fields has long been applied to industrial uses and household and district heating, and in Japan it has been used in experimental fish-farming projects, cleaning, cooking, soil-heating and bathing. Househeating with hot-well water is being developed on a large scale in Japan, the U.S.S.R. and Hungary (where the cost of such heating is reported to be only a fourth of that with fuel-burning systems). The use of geothermal water in air conditioning is based on a process that employs water as the refrigerant and a solution of lithium bromide as a low-temperature absorbent fluid. As in other refrigerating systems the refrigerant is vapor-

ized, thereby extracting heat from the surroundings. Then, however, the refrigerant is taken up by the absorbent. External heat (supplied by geothermal water) drives the refrigerant off the absorbent as a gas; the gas is condensed to liquid, which returns to the evaporator to begin the cycle again. A. N. Tikhonov and I. M. Dvorov reported that a machine of this kind, used in a system providing refrigeration in summer and heat in winter, is being mass-produced in the U.S.S.R. Such a system has also been installed in a hotel in New Zealand, where the energy cost is only a tenth of that for a system using electrically operated compressors.

The third type of geothermal field, called a low-temperature field has only recently begun to receive attention. These fields generally consist of large bodies of water in the range of 50 to 82 degrees C. (120 to 180 degrees F.). They are found in sedimentary deposits, notably in Hungary. The hot water from this type of field is most efficiently used for heating: in houses, greenhouses, mines in cold climates and industrial plants. The use of such water from low-temperature fields in the U.S.S.R. is reported to have represented a saving of about 15 million tons of fuel in 1970.

What will it cost? Because a number of special factors are involved in this new technology, standards for estimating costs have not yet been developed; however, the UN, in response to a proposal made at the symposium on geothermal resources in Pisa in 1970, is expected to appoint a committee of experts to formulate uniform costing procedures, so that costs in various situations and countries can be compared. Some of the costs are already well known from experience. Drilling a steam well costs from $50 to $150 per meter, depending on conditions, so that the drilling cost of a field 1,000 meters deep will be between $50,000 and $150,000 for one well. There are also ready answers on the costs of piping, valves and the various items of equipment for a power plant. The cost of operation for delivery of the heat from a steam field to the plant is likewise well established; with proper management this cost is only about one to three cents per million British thermal units. What, then, are the special costs? The most important are related to the question of the life expectancy of the available heat supply in a field or a given well. There are reasons to believe that with proper management a geothermal field will last for many years, particularly if it is recharged by ground water or by artificial injection of gas or geothermal effluent water. At the present stage of development I believe the lifetime of a typical field can prudently be assumed to be about 30 years for purposes of estimating the amortization of the investment used in developing it. To the initial investment we must add a special cost having to do with maintenance: the wells have to be cleaned regularly and sometimes even redrilled because of the precipitation of chemicals from the steam or hot water.

The experience thus far furnishes some approximate cost figures. In a single-purpose installation producing only electric power at base load, the cost of the power is between three and six mills [1 mill = $0.001] per kilowatt-hour, including full amortization of all the investments over a reasonable period. In desalination plants the cost would probably be in the range of 20 to 50 cents per 1,000 gallons of freshwater yield—far below the costs of other desalination systems. For house-heating, air-conditioning and similar purposes the use of geothermal energy makes possible savings of up to 90 percent or more: a hotel in New Zealand reports that the operating cost of a heating and air-conditioning system based on the use of geothermal energy in a lithium bromide absorption installation is only 12 cents per million kilocalories, as against $2.40 per million kilocalories for an oil-burning system involving approximately the same investment in equipment. These estimates are calculated from the experience of single-purpose facilities. With the development of multipurpose plants, the dividends made possible by extraction of all the benefits in the crude outflow from the geothermal field should reduce the cost of the individual applications.

Not the least of the attractions of geothermal energy is that it can be used at little or no cost to the environment. Unlike fossil or fissionable fuels, it does not pollute the biosphere with combustion products or radiation; unlike hydropower systems, it does not flood fertile lands or generate stresses that may lead to earthquakes. It does present two hazards. The steam and hot water from many fields contain small amounts of boron and other chemicals, which can be harmful when discharged into streams. Trials at the Geysers field and at a geothermal field in El Salvador have shown, however, that the contaminated effluent can be injected back into the field without reducing production from the wells. There is reason to believe this problem will not be difficult to control. The other hazard is that the land may subside where large amounts of water are withdrawn from geothermal reservoirs. This problem too can be controlled, by limiting withdrawals from the field to a safe rate and by recharging it with water, as is now done to prevent subsidence in petroleum fields.

Research

The UN is taking an active interest in geothermal energy. Among all the research needs the paramount one is to develop techniques of exploration to search the earth for geothermal reservoirs, hidden as well as visible. This will call for extensive geological, geochemical and geophysical studies and testing. The UN recently resorted to infrared surveying in a large-scale search from the air for possible geothermal sites in Ethiopia and Kenya. From the standpoint of geology, interest naturally focuses on areas underlain by rocks of high porosity, since these are likely to hold large quantities of water.

From the standpoint of utility and benefit, one hopes to find geothermal reservoirs in arid areas where underground water itself, as well as energy and minerals, would be a boon to the region.

From surface indications alone it appears there are belts of geothermal reservoirs along the western side of the Americas from Alaska all the way down to Chile, in the Middle East (Turkey), in East Africa throughout the African Rift Valley, and in the Far East along the "Circle of Fire" of volcanic activity that surrounds the Pacific Ocean. In Turkey two thirds of the country is believed to have geothermal potential, and there are good prospects for this resource in almost all the countries around the Mediterranean. Recent discoveries by drilling in Europe and elsewhere suggest that a potential exists in many regions that had not previously been considered for exploration. Central America is rich in geothermal resources—indeed, it has more of this potential energy than it could use itself.

On the basis of a reconnaissance, which included airborne infrared scanning, it has been estimated that a part of the Afar region in Ethiopia may have an exploitable geothermal potential sufficient to meet the present need for electric power for the whole of Africa, and other areas in Ethiopia might have a similar geothermal potential. As new information becomes available the magnitude of these energy sources is beginning to be appreciated.

[Excerpted from "Geothermal Power," Scientific American. New York: Scientific American, Inc., Vol. 226, No. 1, January 1972, pp. 70-77.

Solar Energy in Developing Countries

Advisory Panel to NAS on the
Utilization of Solar Energy in
Developing Countries, Manfred
Altman, Chairman

[At the request of the Agency for International Development (AID), an ad hoc international panel convened by the U. S. National Academy of Sciences (NAS) has considered the state of development of processes for utilization of solar energy, their present applications and possible future developments for meeting energy needs in developing countries, and the desirability of establishing international research centers. The panel's conclusions are summarized.]

Solar energy is an energy resource widely available in areas with energy needs in developing countries. It could meet energy needs substantially beyond the applications now being made, but this potential can be realized only with further research and development. Knowledge of the energy needs in developing countries is inadequate; it must be improved, and the research and development programs required to meet these needs should include, but not be limited to, the uses of solar energy. These conclusions led the panel to recommend consideration of the concept of regional energy research and development centers, institutions to study energy needs in their respective regions and to develop the means (including solar) by which these needs might be met. The suggested international solar energy institute in North Africa, if expanded in scope to include other energy sources, could be one such regional center.

Applications of Solar Energy

Some applications of solar energy are well established in developing countries: solar evaporation to produce salt from sea water, a major industry in many areas; and direct solar drying for processing

crops, e.g., to make copra from coconuts. Other applications are established, or becoming established, in more highly developed economies, with the corresponding technologies reasonably well developed. Solar waterheaters are widely used in Australia, Japan, the U.S. (Florida) and Israel; factories making such heaters are found in the first three—in Australia their production is about $1 million a year. Where the need exists, the technology of waterheaters can be, and is being, adapted for use in developing countries and experiments have been made in Chile, Egypt, India, etc. The problem is largely to adapt the technology to use materials and manufacturing capabilities of the country where it is needed. Hot water for hospitals, schools, and other institutions, and for families, could become much more widely available with these developments.

Solar distillation, for producing potable water for human or animal consumption, is generally in a "pilot plant" stage of development but is supplying some small communities with drinking water. A solar still to supply water for animals was built in Las Salinas, Chile in 1872 and reportedly ran for 30 years. In a few small towns or motels in isolated places in Australia, the Mediterranean and Caribbean areas solar stills now supply water on a limited commercial basis. New designs have been developed that require minimal day-to-day attention or maintenance. Further research is required here also for adaptation of existing technology to the specific needs of developing countries, through design modifications to allow use of locally available materials and locally manufactured components. Studies of this type could improve the economics of solar distillation, widen the areas in which it might be useful, and thus contribute to the solution of water-supply problems, particularly for small communities in good climates.

Other applications of solar energy, very much in experimental stages, are subjects for research and development:

- Solar drying, in recently developed enclosures to control the process and enhance product quality, may result in improved handling and utilization of foods.
- Solar heating and cooling of buildings is rather little developed. About 15 experimental solar-heated houses have been built, and economic studies made applying to a few developed countries. Solar air-conditioning appears to be technically feasible; economic feasibility is now under study. It has been suggested that air-conditioning of factories and offices in developing countries could improve productivity. For both heating and cooling, scientific principles for control of solar thermal effects may be usefully introduced into building designs.
- Solar cooking appears to be simple in technology, and designs have been tried out for some years with satisfactory technical

performance. But extensive field trials in India, Mexico and Morocco have so far not resulted in social acceptance; after an initial period, users revert to their traditional cooking methods. Energy-storage or heat-transfer techniques to permit indoor or evening cooking might help solve acceptance problems.

- Solar refrigeration for preservation of food and medical supplies, obtained by absorption cooling cycles, appears to be technologically feasible. The best systems and cycles have yet to be determined, as have the best scale of application and social and economic feasibility.
- Solar power systems, for generating electricity based on heat engines, are still a difficult challenge. Research on these processes is of a more difficult and speculative nature; the potential returns are larger, but so also are the problems in developing useful and economic systesm.
- Photovoltaic conversion of solar to electrical energy is highly developed for space-vehicle use, but is far too expensive now for large-scale terrestrial use. It is now useful, however, for some highly specialized, very low-power applications, as in some applications to communications. Photovoltaic process research is best done in developed countries, and its potential contribution to energy economies of developing areas, other than for communication purposes, cannot be foreseen with present technological practice.
- Biological processes, for specially controlled agriculture or for industrial cultures of algae, water hyacinth, or sea weed (as in Japan), are another class of solar processes that might become significant.

To summarize, the solar processes that are now useful or that could be developed to produce useful results in the shortest time are: evaporation, drying, distillation, and waterheating. More extensive development of processes for refrigeration, new methods of solar drying, heating and cooling, and thermal design of buildings should make some of these uses practical within the decade. Solar electrical power, however, will require substantial development of technology [see pp. 27-29].

Some General Considerations

Total energy resource needs for the next 20-30 years are now being projected for many countries, and serious questions are being raised as to whether the industrialized countries can continue to use, at present and projected rates, the fossil fuel and nuclear energy sources now available to them. Pollution is a real problem; countries which today are major energy-resource suppliers may be less eager in the future to share their now-abundant energy sources. Other populous nations, such as India or China, compete for shrinking supplies of

natural resources. Aspirations, energy needs, and resource utilization are highly time-dependent, and the needs of the large part of the world's population in the developing countries cannot, in the long run, be considered independently from energy planning in the indusrialized nations.

The process reliability of solar processes is of primary importance. There are more or less predictable reliability problems arising out of weather variability and energy (or other product) storage requirements. Desirable degrees of reliability can be designed into solar processes, depending on solar energy availability (i.e., climate) and on costs. A second set of reliability criteria is that the process perform as intended over extended periods of time, e.g., the anticipated lifetime used in calculating the annual capital costs of the process. Developing countries should not be expected to expend their very limited capital resources on a solar device unless they have adequate assurance that it will perform for those extended periods; process engineering must be adequate. The capital-intensive nature of solar processes, in comparison with energy systems using conventional fuels, should be noted.

Two approaches to solar-energy applications have developed: one approach has been to develop simple, inexpensive, household-scale devices, designed to be made with local labor and materials on an individual or very small scale. The other approach has been to design more carefully engineered systems with controlled manufacture, often factory produced, and sometimes for larger-scale applications. At present more useful solar-energy applications fall into the second category. Extensive efforts to develop applications for individuals have not enjoyed much success, except for solar waterheaters which have been factory produced. Experience suggests that carefully engineered and manufactured systems are more likely to affect developing countries in the next decade; this is the more fruitful approach. The best route to solar applications may be through systems designed for the middle and upper classes, or for community or industrial users, with the expectation that success there might lead to ultimate applications by the less affluent or smaller-scale users. Similarly, it is likely that some solar applications will result from technology developed for use in industrialized areas modified for the developing countries. Small-scale applications on a household scale should not be ruled out, but it will probably take longer to realize their benefits.

[Excerpted from Solar Energy in Developing Countries: Perspectives and Prospects. Washington (D. C.): National Academy of Sciences, March, 1972, pp. 1-3 and 26-30.]

Solar Energy: A Feasible Source of Power?

Allen L. Hammond

[Although solar energy has not yet been successfully harnessed as a source of electric power, some recent technical advances are making this power source a closer and more interesting possibility than ever before.]

Hopes for utilizing energy from the sun on a large scale have never materialized in the past. Recent discussions of how to meet growing U. S. national energy needs have focused on atomic fission breeder reactors and fusion reactors as the best long-range replacements for fossil fuels, and have usually dismissed solar energy altogether. However, a new proposal for a solar energy system has been attracting considerable attention among officials. The proposed system would capture the sun's energy extremely efficiently by means of specially coated collecting surfaces, which would be heated by the resulting super "greenhouse" effect to temperatures as high as 540°C; the heat energy would be collected and stored in a thermal reservoir, to which conventional steam boilers, turbines, and electrical generating equipment would be attached. Although several key questions remain to be answered, preliminary calculations indicate that such a system may well be technically and economically feasible.

The proposed new solar energy system was designed by two astronomers, Aden B. Meinel, director of the Optical Sciences Center of the University of Arizona at Tucson, and Majorie Meinel. It would op-

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erate at much higher temperatures than those of earlier solar energy schemes, and might attain a 25 to 30 percent overall efficiency of conversion of incident sunlight to electricity.

In the relatively cloudless deserts of the southwestern United States, the solar energy flux reaching the earth's surface averages about 0.8 kilowatt per square meter for the middle 6 to 8 hours of day during most of the year. An ordinary black surface absorbs most of this energy, but much is reemitted as thermal radiation. It is the spectral differences between the incident and reemitted radiation that makes efficient use of solar energy possible. The incident energy flux has a maximum at a wavelength of about 0.5 micrometer, near the center of the visible region—0.4 to 0.7 micrometer—but the flux decreases rapidly toward the red end of the spectrum. The thermal reemission is mostly in the infrared wavelengths, with a peak near 5 micrometers at the temperatures envisioned for the collecting system. Hence highly selective coatings, that are black in the visible and are poor emitters in the infrared, are able to absorb essentially all of the incident sunlight but give off almost nothing.

There appear to be many ways of making suitable coatings from layers of thin films deposited on a steel collecting surface by evaporation techniques. One type of coating developed recently by Bernard Seraphin at the University of Arizona depends on the intrinsic properties of materials. An example of this type of coating consists of a semiconductor material that is opaque to visible light but transparent to infrared; underneath the semiconductor layer would be another layer of a material, such as gold, which has a very low emissivity in the infrared. Because of the transparency of the semiconductor to infrared radiation, the composite coating would act like a mirror—a desirable property because high reflectivity corresponds to low emissivity—in the infrared.

The collecting surfaces in the proposed system would be enclosed in a vacuum to eliminate convective cooling. Liquid sodium would be pumped through channels in the steel to transport the heat to a tank containing a eutectic mixture of molten salts, which, like a giant water-ice system, can maintain a constant temperature over a wide range of energy storage. This would provide a reservoir from which energy could be drawn by the steam turbine as required, so that operation overnight and for short periods of cloudy weather would be possible. According to the Meinels' estimates, about 8 square kilometers of collecting surface and a 50-million-liter thermal storage tank would be required for the equivalent of a 1000-megawatt generating plant—a size comparable to nuclear power plants being built today. The largest question as to the technical feasibility of the proposed system appears to concern the durability of the thin film coatings.

Solar energy systems have no fuel costs, but they require higher initial investments in equipment than do other energy systems. In addition, the cost of manufacturing thin film coatings on a large scale has always been prohibitive in the past, because of the high vacuum and large currents required. Recently, however, large continuous evaporators have become available and are now used to coat such products as architectural glass. If a commitment were made to utilize solar energy on a sufficient scale, so that a large manufacturing plant could be built to produce the collecting surface, then, Meinel estimates, the unit costs should decrease to the point that electricity from solar energy would be economically attractive—in the range from 5 to 10 mils per kilowatt-hour, exclusive of distribution costs. Comparable figures for fossil fuels range from 1.5 to 5 or more mils per kilowatt-hour at present. Although in the U.S. solar energy plants would be restricted to the southwestern deserts, developments in cryogenic or superconducting power transmission lines could make the power available to a larger region.

Solar energy systems are environmentally attractive because they do not contribute to air pollution, and because they avoid the radioactivity hazards of nuclear power systems. However, solar energy systems would still require cooling water for the steam turbines, so that thermal pollution would potentially still be present. Meinel envisions dual-purpose plants that could use the waste heat for industrial or agricultural purposes, or for running evaporators to produce fresh water by desalinization. It is still too early to make accurate assessments of the economic feasibility of solar energy, but the prospects appear to be encouraging enough to warrant further research. Similar economic questions remain to be resolved about atomic breeder reactors, and fusion power systems have yet to be proved scientifically feasible, so that solar energy must be considered a significant, if still uncertain, alternative for future power needs.

[Excerpted from "Solar Energy: A Feasible Source of Power?," Science. Washington (D.C.): the American Association for the Advancement of Science, Vol. 172, No. 3984, 14 May 1971, p. 660.

The Energy Resources of the Earth

M. King Hubbert

[Industry is using up at an increasing rate the world's fossil fuels created slowly over millions of years. There are several interesting alternative energy sources for use when these fuels become scarce; nuclear power seems to have the largest scope.]

Energy flows constantly into and out of the earth's surface environment from solar radiation. The leaves of plants capture a small fraction of the incident solar radiation and store it chemically by the mechansim of photosynthesis. This store becomes the energy supply essential for the existence of the plant and animal kingdoms. Biologically stored energy is released by oxidation at a rate approximately equal to the rate of storage. Over millions of years, however, a minute fraction of the vegetable and animal matter is buried under conditions of incomplete oxidation. These organic materials that did not immediately decay, buried under a great thickness of sedimentary sands, muds and limes, are the fossil fuels: coal, oil shale, petroleum and natural gas, which are rich in energy stored up chemically from the sunshine of the past 600 million years. The process is still continuing, but probably at about the same rate as in the past; the accumulation during the next million years will probably be a six-hundredth of the amount built up thus far.

Industrialization has withdrawn the deposits in this energy bank with increasing rapidity. In the case of coal, the amount of coal produced and consumed since 1940 is approximately equal to the total consumption up to that time. The cumulative production from 1860

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through 1970 was about 133 billion metric tons, while the amount produced before 1860 was about seven billion metric tons. Petroleum and related products were not extracted in significant amounts before 1880. Since then production has increased at a nearly constant exponential rate; the average rate of increase during 1890-1970 has been 6.94 percent per year. The cumulative production through 1969 amounted to 227 billion barrels: 102 years from 1857 to 1959 were required to produce the first half of this cumulative production; only the 10 years from 1959 to 1969 were required for the second half.

How Long Can Fossil Fuels Last?

Broadly speaking, the world's consumption of energy for industrial purposes is now doubling approximately once per decade. When confronted with a rate of growth of such magnitude, one can hardly fail to wonder how long it can be kept up. In the case of the fossil fuels a reasonably definite answer can be obtained. Their human exploitation consists of their being withdrawn from an essentially fixed initial supply. During their use as sources of energy they are destroyed. The complete cycle of exploitation of a fossil fuel would have the following characteristics: beginning at zero, the rate of production tends initially to increase exponentially; then, as difficulties of discovery and extraction increase, the production rate slows in its growth, passes one maximum or more and, as the resource is progressively depleted, declines eventually to zero. If known past and prospective future rates of production are combined with a reasonable estimate of the amount of a fuel initially present, one can calculate the probable length of time that the fuel can be exploited.

In the case of coal, reasonably good estimates of the amount present in given regions can be made on the basis of geological mapping and a few widely spaced drill holes, inasmuch as coal is found in stratified beds or seams that are continuous over extensive areas. Such studies have been made in all the coal-bearing areas of the world. The most recent compilation of the present information on the world's initial coal resources was made by Paul Averitt of the U. S. Geological Survey. His figures (see Table 1) represent minable coal, which is defined as 50 percent of the coal actually present. Included is coal in beds as thin as 14

Table 1: Estimated Coal Resources

(in billions of metric tons)

USSR	4,310
U. S.	1,486
Asia (non-Soviet)	681
Canada	601
Western Europe	377
Africa	109
Oceania	59
Latin America	14
WORLD	7,637

SOURCE: Paul Averitt of the U. S. Geological Survey, 1969.

inches (36 centimeters) and extending to depths of 4,000 feet (1.2 kilometers) or, in a few cases, 6,000 feet (1.8 kilometers).

Taking Averitt's estimate of an initial supply of 7.6 trillion metric tons, and assuming that the present production rate of three billion metric tons per year does not double more than three times, one can expect that the peak in the rate of production will be reached sometime between the years 2100 and 2150. The length of time required to produce the middle 80 percent will be roughly the 300-year period from 2000 to 2300—see Figure 1.

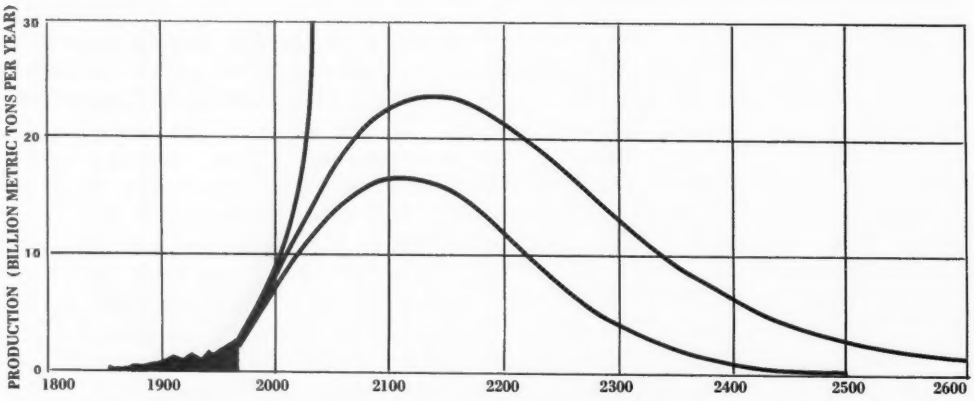

Figure 1: CYCLE OF WORLD COAL PRODUCTION is plotted on the basis of estimated supplies and rates of production. The top curve reflects Averitt's estimate of 7,600 billion metric tons as the initial supply of minable coal; the bottom curve reflects an estimate of 4,300 billion metric tons. The curve that rises to the top of the graph shows the trend if production continued to rise at the present rate of 3.56 percent per year. The amount of coal mined and burned in the century beginning 1870 is shown by the black area at left.

Estimating the amount of oil and gas that will ultimately be discovered and produced in a given area is considerably more hazardous than estimating for coal. The reason is that these fluids occur in restricted volumes of space and limited areas in sedimentary basins at all depths from a few hundred meters to more than eight kilometers. Nonetheless, the estimates for a given region improve as exploration and production proceed. In addition it is possible to make rough estimates for relatively undeveloped areas on the basis of geological comparisons between them and well-developed regions. A large mass of data has been accumulated in the U.S. and a number of different methods of analysis have been developed that give fairly consistent estimates of the degree of advancement of petroleum exploration and of the amounts of oil and gas that may eventually be produced.

One such method is based on the principle that only a finite number of oil and gas fields existed initially in a given region. As exploration proceeds the shallowest and most evident fields are usually

discovered first and the deeper and more obscure ones later. Hence the amount of exploratory activity required to discover a fixed quantity of oil or gas steadily increases. Most new fields are discovered by what the industry calls "new-field wildcat wells," meaning wells drilled in new territory that is not in the immediate vicinity of known fields. In the U. S. statistics have been kept annually since 1945 on the number of new-field wildcat wells required to make one significant discovery of oil or gas ("significant" being defined as one million barrels of oil or an equivalent amount of gas). The discoveries for a given year are evaluated only after six years of subsequent development. In 1945 it required 26 new-field wildcat wells to make a significant discovery; by 1963 the number had increased to 65.

Another method is to consider the amount of oil discovered per foot of exploratory drilling. From 1860 to 1920, when oil was fairly easy to find, the ratio was 194 barrels per foot. From 1920 to 1928 the ratio declined to 167 barrels per foot. Between 1928 and 1938, partly because of the discovery of the large East Texas oil field and partly because of new exploratory techniques, the ratio rose to its maximum of 276 barrels per foot. Since then it has fallen sharply to a nearly constant rate of about 35 barrels per foot. Yet the period of this decline coincided with the time of the most intensive research and development in petroleum exploration and production in the history of the industry. The cumulative discoveries in the 48 states up to 1965 amounted to 136 billion barrels. From this record of drilling and discovery it can be estimated that the ultimate total discoveries in the coterminous U. S. and the adjacent continental shelves will be about 165 billion barrels. The discoveries up to 1965 may therefore represent 82 percent, and probably at least 75 percent, of the ultimate amount of oil to be produced in this area.

For natural gas in the 48 states, the present rate of discovery, averaged over a decade, is about 6,500 cubic feet per barrel of oil. Assuming the same ratio for the estimated ultimate amount of 165 billion barrels of crude oil, the ultimate amount of natural gas would be about 1,075 trillion cubic feet. Combining the estimates for oil and gas with the trends of production makes it possible to estimate how long these energy resources will last. In the case of oil the period of peak production appears to be the present. The time span required to produce the middle 80 percent of the ultimate cumulative production is approximately the 65-year period from 1934 to 1999—less than the span of a human lifetime. For natural gas the peak of production will probably be reached between 1975 and 1980. The discoveries of petroleum in Alaska modify the picture somewhat. A rough speculative estimate can be made of the eventual discoveries of petroleum in Alaska as 30 to 50 billion barrels. One must bear in mind, however, that 30 billion barrels is less than a 10-year supply for the U. S. at the present rate of consumption.

Estimates of ultimate world production of oil, covering areas far less explored than the U.S., range from 1,350 billion barrels to 2,100 billion barrels. For a geographical breakdown of the latter figure, see Table 2. For the higher figure the peak in the rate of world production would be reached about the year 2000. The period of consumption of the middle 80 percent will probably be some 58 to 64 years, depending on whether the lower or the higher estimate is used—see Figure 2.

Table 2: Estimated Petroleum Resources

(in billions of barrels)

Middle East	600
USSR and China	500
Africa	250
Latin America	225
Far East	200
U.S.	200
Canada	95
	2,070

SOURCE: W. P. Ryman of the Standard Oil Co. of New Jersey, in 1967.

A substantial but still finite amount of oil can be extracted from tar sands and oil shales, a field where production has barely begun. A world summary of oil shales by Donald C. Duncan and Vernon E. Swanson of the U.S. Geological Survey indicated a total of about 3,100 billion barrels in shales containing from 10 to 100 gallons per ton, of which 190 billion barrels were considered to be recoverable under 1965 conditions.

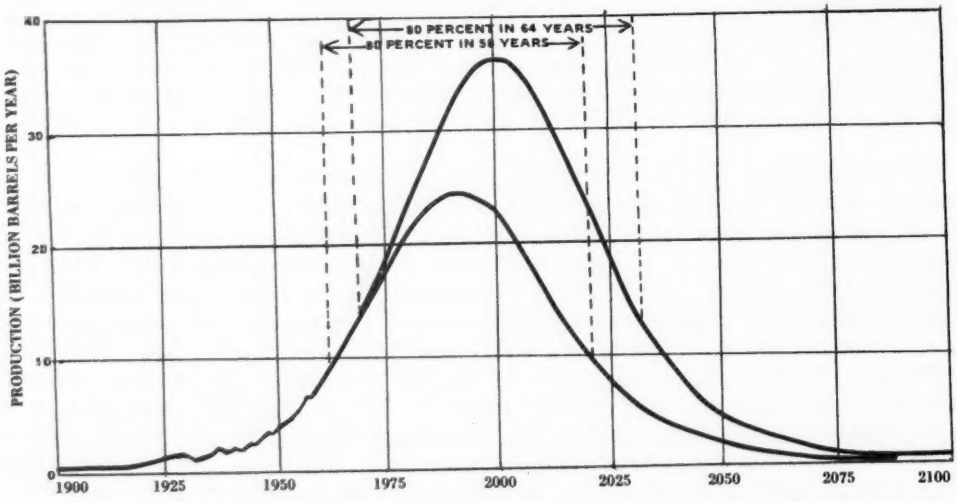

Figure 2: CYCLE OF WORLD OIL PRODUCTION is plotted on the basis of two estimates of the amount of oil that will ultimately be produced. The upper curve reflects Ryman's estimate of 2,100 billion barrels and the lower curve represents an estimate of 1,350 billion barrels.

Alternatives to Fossil Fuels

Since the fossil fuels will inevitably be exhausted, probably within a few centuries, the question arises of what other sources of energy can be tapped to supply the power requirements of a moderately industrialized world after the fossil fuels are gone. Five forms of energy appear to be possibilities: solar energy used directly, solar energy used indirectly, tidal energy, geothermal energy and nuclear energy.

Until now the direct use of solar power has been on a small scale for such purposes as heating water and generating electricity for spacecraft by means of photovoltaic cells. Much more substantial installations will be needed if solar power is to replace the fossil fuels on an industrial scale, i.e., solar power plants in units of say, 1,000 megawatts. Provision must also be made for large-scale storage of energy in order to smooth out the daily variations in sunlight. The most favorable sites for developing solar power are desert areas in the southwestern U.S., the region extending from the Sahara across the Arabian Peninsula to the Persian Gulf, the Atacama Desert in northern Chile, and central Australia. These areas receive some 3,000 to 4,000 hours of sunshine per year, and the amount of solar energy incident on a horizontal surface ranges from 300 to 650 calories per square centimeter per day.

Three schemes for collecting and converting this energy in a 1,000-megawatt plant can be considered [see pp. 27-29 for description of one of these schemes]. Estimated thermal efficiencies with these three methods are 10, 20 and 30 percent. Over this range of efficiencies the amount of thermal power that would have to be collected for a 1,000-megawatt plant would range from 10,000 to 3,300 thermal megawatts. Accordingly the collecting areas for the three schemes would be 70, 35 and 23 square kilometers respectively. With the least of the three efficiencies the area required for an electric-power capacity of 350,000 megawatts—the approximate capacity of the U.S. in 1970—would be 24,500 square kilometers, which is somewhat less than a tenth of the area of Arizona. The physical knowledge and technological resources needed to use solar energy on such a scale are now available. The technological difficulties of doing so, however, should not be minimized.

Using solar power indirectly means either relying on the wind, which appears impractical on a large scale, or on the streamflow part of the hydrologic cycle. At first glance the use of streamflow appears promising, because the world's total water-power capacity in suitable sites is estimated at about three trillion watts, which approximates the present use of energy in industry. Only 8.5 percent of this water power is developed for hydroelectricity at present. The

three regions with the greatest potential—Africa, South America and Southeast Asia—are among the least developed industrially.

Tidal power is obtained from the filling and emptying of a bay or an estuary that can be closed by a dam. The enclosed basin is allowed to fill and empty only during brief periods at high and low tides in order to develop as much power as possible. A number of promising sites exist; their potential capacities range from two megawatts to 20,000 megawatts each. The total potential tidal power, however, amounts to about 64 billion watts, which is only 2 percent of the world's potential hydroelectric power. The only full-scale tidal-electric plant built so far is on the Rance estuary on the Channel Island coast of France. Its capacity at start-up in 1966 was 240 megawatts; an ultimate capacity of 320 megawatts is planned.

Geothermal power is obtained by extracting heat that is temporarily stored in the earth by such sources as volcanoes and the hot water filling the sands of deep sedimentary basins. [See article on pp. 17-22.] Only volcanic sources are significantly exploited at present. Donald E. White of the U.S. Geological Survey has estimated that the stored thermal energy in the world's major geothermal areas amounts to about three million megawatt-years. If this energy, which is depletable, were withdrawn over a period of 50 years, the average annual power production would be 60,000 megawatts—which is comparable to the potential tidal power.

Nuclear power must be considered under the two headings of fission and fusion. Fission involves the splitting of nuclei of heavy elements such as uranium, while fusion involves the combining of light nuclei such as deuterium. Uranium 235, which is a rare isotope (each 100,000 atoms of natural uranium include six atoms of uranium 234, 711 atoms of uranium 235 and 99,283 atoms of uranium 238), is the only atomic species capable of fissioning under relatively mild environmental conditions, that is, the conditions found in most atomic power plants now in operation. If nuclear energy depended entirely on uranium 235, the nuclear-fuel epoch would be brief. By breeding, however, wherein by absorbing neutrons in a nuclear reactor uranium 238 is transformed into fissionable plutonium 239, or thorium 232 becomes fissionable uranium 233, it is possible to create more nuclear fuel than is consumed. With breeding, the entire supply of natural uranium and thorium would thus become available as fuel for fission reactors.

Most of the reactors now operating or planned in the rapidly growing nuclear-power industry in the U.S. and elsewhere depend essentially on uranium 235. The International Atomic Energy Agency projects requirements of 430,000 short tons of uranium oxide for the non-Communist nations during the expected growth from 1970 to 1980.

Against these requirements the world reserves of uranium oxide producible at $10 per pound or less are estimated at 840,000 tons. The same report estimates that to meet future requirements additional reserves of more than a million short tons will have to be discovered and developed by 1985. Although new discoveries of uranium will doubtless continue to be made (a large one was recently reported in Australia), all present evidence indicates that without a transition to breeder reactors an acute shortage of low-cost ores is likely to develop before the end of the century.

An intensive effort to develop large-scale breeder reactors for power production is in progress. If it succeeds, the situation with regard to fuel supply will be drastically altered. This prospect results from the fact that with the breeder reactor the amount of energy obtainable from one gram of uranium 238 is equal to the heat of combustion of 2.7 metric tons of coal or 13.7 barrels (1.9 metric tons) of crude oil. Let us consider the abundant low-grade uranium ores; one example will indicate the possibilities.

Chattanooga black shale crops out along the western edge of the Appalachian Mountains and underlies at minable depths most of five U.S. states. In its outcrop area in eastern Tennessee this shale contains a layer about five meters thick that has a uranium content of about 60 grams per metric ton; that amount of uranium would be equivalent to about 162 metric tons of bituminous coal or 822 barrels of crude oil. With the density of the rock some 2.5 metric tons per cubic meter, the energy content of the shale per square meter of surface area would be equivalent to about 2,000 tons of coal or 10,000 barrels of oil; allowing for a 50 percent loss in mining and extracting the uranium, we are still left with the equivalent of 1,000 tons of coal or 5,000 barrels of oil per square meter. Taking Averitt's estimate of 1.5 trillion metric tons for the initial minable coal in the U.S. and a round figure of 250 billion barrels for the petroleum liquids, and adding natural gas and oil shales, an area of roughly 2,000 square kilometers of Chattanooga shale would be equivalent to the initial supply of all the fossil fuels in the U.S. That area is about 2 percent of the area of Tennessee, and a very small fraction of the total area underlain by the shale.

Many other low-grade deposits of comparable magnitude exist in the U.S. and in other areas. Hence by means of the breeder reactor, the energy potentially available from the fissioning of uranium and thorium is many times greater than that from all the fossil fuels combined.

David J. Rose of the AEC (U.S. Atomic Energy Commission), reviewing recently the prospects for controlled fusion, found the deuterium-tritium reaction to be the most promising. Deuterium is

abundant (one atom to each 6,700 atoms of hydrogen), and the energy cost of separating it would be almost negligible compared with the amount of energy released by fusion. Tritium, on the other hand, exists only in tiny amounts in nature; larger amounts must be made from lithium. Considering the amount of hydrogen in the oceans, deuterium can be regarded as superabundant, and its extraction is easy. Lithium is much less abundant, however; it is produced from geologically rare igneous rocks known as pegmatites and from the salts of saline lakes. The measured, indicated and inferred lithium resources in the U.S., Canada and Africa total 9.1 million tons of elemental lithium; from this amount, the fusion energy obtainable is approximately equal to the energy content of the world's fossil fuels.

As long as fusion power is dependent on the deuterium-tritium reaction, which now appears to be somewhat the easier because it proceeds at a lower temperature, the energy obtainable from this source appears to be of about the same order of magnitude as that from fossil fuels. But if fusion can be accomplished with the deuterium-deuterium reaction, the picture will be markedly changed. One cubic meter of water contains about 10^{25} atoms of deuterium having a potential fusion energy equivalent to the heat of combustion of 300 metric tons of coal or 1,500 barrels of crude oil. A cubic kilometer contains a billion cubic meters; the total volume of the oceans is about 1.5 billion cubic kilometers. If enough deuterium were withdrawn to reduce the initial concentration by only 1 percent, the energy released by fusion would amount to about 500,000 times the energy of the world's initial supply of all fossil fuels!

The Role of Nuclear Power in Meeting World Energy Needs

B. I. Spinrad

[Over the next 40 years the evolving technology of nuclear power generation, and the existing and expected low costs of fuel and transportation, should make nuclear power plants a fast growing and eventually a dominant element in world energy uses.]

Both advanced countries and developing countries have significant energy requirements, those of the developing countries being very much greater in the long run considering that they represent a large fraction of the world's population. Indeed, one would have to approximately triple the world's production of manufactured energy now to bring all citizens of the world up to minimum energy use standards in advanced countries. Considering both population growth and increasing standards, manufactured energy in the world will probably have to increase about 7 percent a year for a very long time. This paper is concerned with the role of nuclear power in this scheme of things. For the most part, nuclear power is conceived as a source of electricity generated in large thermal stations. We are discussing the future, and I shall therefore be extrapolating. This is always dangerous with a technology which is still developing, as nuclear power is doing. I can only provide estimates based on the dim technical foresight of today; no apology is necessary, but this warning must be emphasized.

Nuclear Forecasts

Presented here are the main results of the process by which the growth of nuclear power in the world has

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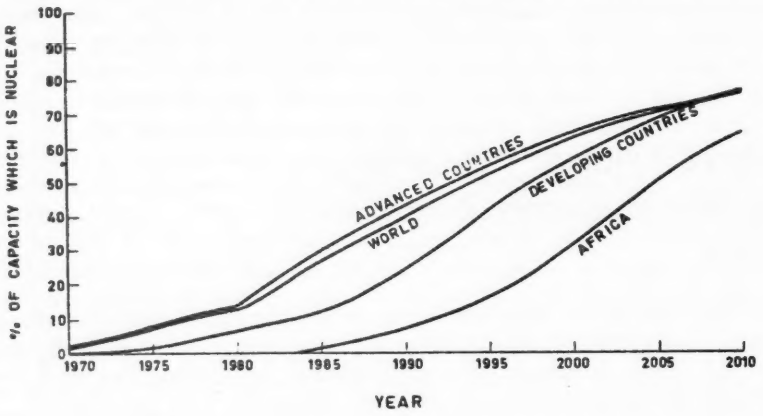
Figure 1: Nuclear Share of Electrical Engineering Capacity



been estimated. These are the actual forecasts of the International Atomic Energy Agency (IAEA—a UN Specialized Agency) which, although made in a highly subjective fashion, are defensible as the result of a well-defined predictive process, and they are not seriously divergent from several other such attempts. The basic forecast is divided into two parts: 1970-1985, and 1985-2010. The former period is within the range where specific plans can be collected, assessed and summed (it involves evaluation of nuclear plant orders in 1965-1980), while in the second period more general analysis is necessary. The IAEA is engaged in a study of the requirements for financing arising from the plans of developing countries to build nuclear power plants. Information is presented to us by the countries as to their expected or planned nuclear generating capacities. These plans have been processed by us, in a generally conservative fashion to allow for project delays and imperfect market penetration; so that, as far as developing countries are concerned, our figures may be somewhat cautious. Some checking is possible: the Agency maintains a continuing forecast of its own, based on unofficial market extrapolations, nuclear news information, and the balanced judgments of the many experts available to the Agency. This forecast agrees in general with that adduced from national data. Table 1 sets out the forecasts for the world up to 1985, followed by a region-by-region extrapolation to 2010 [discussion of forecast methods omitted].

The forecast indicates that we are, right now, at the threshhold of a period in which the "standard" electric power station will be nuclear. There are three qualitative reasons for expecting this to be so, and one for the converse. The pros are:

a) The intrinsic cost of nuclear energy, in terms of the energy available from the U^{235} extracted from natural uranium, is one tenth to one fifth of that for competitive fossil fuels.

Table 1: Expected Electrical Capacity, by Region, 1970 to 2010; and Expected Percentage Shares of Nuclear Power in Total

	Developing Regions					Advanced Regions				
	Africa	Asia[a]	Eastern Europe[b]	Latin America	Total Developing Regions[a]	North America	Western Europe	USSR	Other Advanced Regions[c]	World Total[a]
Electrical Generating Capacity (in billions of watts)										
1970	12	38	38	39	127	390	290	170	89	1,066
1980	30	109	76	88	305	750	550	380	198	2,581
1990	65	270	152	175	670	1,283	948	735	396	4,032
2000	136	609	305	343	1,393	1,920	1,446	1,248	792	6,799
2010	285	1,242	610	684	2,821	2,610	1,993	1,888	1,524	10,896
Share of Nuclear Power Plants in Total Capacity (%)										
1970	0	0.5	0	0	0.4	2.6	3.6	1.0	1.5	2.2
1980	0	10	7.2	6.8	7.3	21	18	11	12	13
1990	5	24	28	27	25	44	42	44	40	40
2000	45	58	60	61	57	64	63	65	67	63
2010	64	77	77	77	76	75	75	75	80	76

a/ Excludes Mainland China.

b/ Includes Greece and Turkey; excludes East Germany.

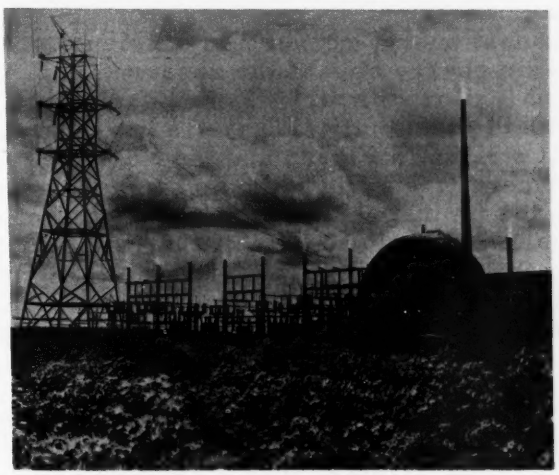
c/ Australia, Japan, New Zealand, South Africa.

b) The intrinsic compactness of nuclear fuel makes it eminently portable, and reduces transport costs of fuel and effluent to an almost insignificant matter.

c) The effluent from nuclear energy, in the form of fission products, is as compact as the fuel, and the enrivonmental impact of nuclear energy is thereby minimized.

The main reason for being skeptical about nuclear energy is that nuclear power plants are intrinsically more complex than fossil-fuel plants and, therefore, require higher capital investment. Let us examine each of these points in turn.

Resources. While uranium is one of the less abundant materials on the earth's crust, this crust is large and the material is ubiquitous. Its abundance is usually taken as two parts per million (ppm). It is a "lithophile" element whose concentration varies with



180,000-kilowatt nuclear power station, Dresden, Illinois. [Photo: Commonwealth Edison.]

type of rock. Of the surface rocks, it is most commonly seen in granites; although the concentration is low, the quantity of granite containing 5-10 ppm is so huge that, if uranium could be extracted from it, the supply would be inexhaustible. The concentration of uranium in sea water is also low, but this may turn out to be extractable at a reasonable price some day. The current market price for uranium is about U.S. $18 per kg. of contained uranium oxide (U_3O_8). The supply of uranium at this price, which corresponds to ore bodies containing several hundred to a few thousand ppm of uranium, is limited; but given an incentive to continue exploration, there is every expectation that enough more will be found to fuel all of the converter reactors the world expects to build for the next 30 years. During this period, the price might rise to $30/kg. (1970 U.S. dollars). A joint working party from the IAEA and the European Nuclear Energy Agency published a report in 1967 which indicated 825,000 short tons of uranium oxide as reasonably assured world reserves and 740,000 tons as estimated additional, all at prices less than $10/lb. ($22/kg.). At prices between $10 and $30/lb. they indicated a combined "assured" and "estimated additional" reserve of 3,400,000 short tons of uranium oxide. In 1970 they met again and reported very similar figures in the lower price ranges, in spite of appreciable consumption in the interim. These reserves will meet fuel requirements up to about 1980.

One kilogram of uranium contains about 7 grams of U^{235}, which is the thermally fissionable isotope. Thus each gram of U^{235} costs about $3. The fission of this gram produces about one megawatt-day of thermal energy, or about 300 kilowatt-days of electricity at modest energy conversion efficiency. From uranium, then, the basic energy cost of the resource is 0.4 mills/kwh (one mill = $0.001; kwh = kilowatt hour). Fossil-fuel costs run between 2 and 4 mills/kwh of electricity. There is little reason to believe that the recent oil strikes in Alaska and the North Sea will lead to drastically lower prices. Thus, uranium as an energy source is a very cheap mineral. In the future, moreover, breeder reactors will effectively use as fuel all of the uranium, rather than the one part in 139 which is U^{235}; so that breeder reactors could tolerate such prices as $3000/kg. as far as energy supplies are concerned. On the other hand, the most pessimistic estimates for the cost of uranium from the rocks or the sea do not exceed a few hundred dollars per kilogram.

Fuel cycle. The problem, and the challenge to the nuclear industry, has been how to capitalize on this low resource cost for actual use. The uranium must be purified, chemically prepared as a fuel material, mechanically fabricated into reactor fuel. It may require enrichment. After only partial consumption of the fissile material content, it must be reprocessed to recover the remaining uranium and by-product plutonium. Reactor designs are sensitive to the costs

of all these processes, and the breakdown of fuel cycle costs is different for each reactor type. It is instructive to present these costs for several current reactor types in 1975 and 1985; the overall fuel costs in 1975 covering the whole fuel cycle come to 1.22-1.28 mills/kwh in two leading types of U.S. reactor, and similarly in the principal reactor made in the U.K.; these costs are unlikely to fall much by 1985. However, in a CANDU reactor developed in Canada, the 1975 costs are 0.70 mills/kwh, with a prospective drop to 0.48 mills/kwh by 1985. (Note: the low fuel cost is offset by higher capital cost of the CANDU reactor.)

The reactors of today, just referred to, are low-enrichment thermal reactors. By 1985, fast breeder reactors are expected to be entering the nuclear market, and their resource cost for the foreseeable future will be completely trivial. But one of the major problems with fast breeder reactors is that enormous quantities of plutonium are needed to keep them critical, and, therefore, fuel inventory costs replace resource costs as a major fuel-cycle cost factor. Taking this into account, fuel cycle costs for fast breeder reactors at three different times are estimated as follows: 2.76 mills/kwh in 1970, which is achievable now; 0.87 mills/kwh in 1985 represents current development targets; and 0.37 mills/kwh in 2000 represents a mature nuclear industry in which full credit is taken for economies of scale and for technological improvements. It should be noted that the "1985" fast reactor fuel cycle cost targets are appreciably lower than those for thermal reactors; thus there should by then be the beginnings of a market penetration, which would be complete in less than 10 years. The uncertainty relates to relative capital costs.

Fuel portability. The influence of fuel portability is felt, in the case of nuclear power, in the essential absence of transportation charges from the costs of the fuel cycle. Uranium fuel elements cost the same anywhere in the world and they provide 10,000 to 100,000 megawatt-days of thermal energy per ton of fuel. Even considering fixtures and fittings and shipping cases, and using only a 30 percent heat-to-electricity conversion efficiency, at $1000 per ton (which is higher than air-freight rates to just about anywhere), one gets numbers less than 0.04 mills/kwh as fuel shipping charges.

Contrast this with oil. Using supertankers or very large pipelines, transport contributes about 0.25-0.30 mills/kwh to the cost of electricity. But supertankers and pipelines are only worth building when volume of shipment justifies it, and these low transport prices only pertain to existing industrial centers and modern deep-water ports. If a power station is to be built in any location but at portside or pipeline head, local transportation charges can be several times higher than the cost of shipping oil halfway around the world. Thus

oil, the cheapest fossil fuel to transport, is a strong competitor to nuclear fuel in existing industrialized areas, but it is less attractive for areas which are becoming industrialized, either in developing countries or in new regions of advanced ones. The transport network required and the handling facilities represent considerable capital investment.

Portability and storage of effluent. Certain facts concerning nuclear effluent (i.e., the waste materials left behind by the process of atomic power generation) underlie our confidence that it is manageable at very low cost:

a) The physical quantity of effluent is dramatically small. A nuclear power station produces as "ashes" fission products; but these weigh no more than the fuel which is burned. From a 1,000 MW station, the fission product quantity after three years of steady operation is of the order of 4 tons, and can be physically confined in a single (albeit red-hot) carload.

b) Most of the fission-products are either stable nuclei, or their radioactivity decays to stable nuclei so rapidly that less than 10 percent of them require special long-term attention.

c) All fission products are physically transported from the reactor and chemically extracted at a remote location. Costs of this transport, and of permanent management of radioactive effluent, are already included in the fuel cycle costs cited above, and are not a large contributor to the charges listed.

d) The physical quantity of radioactive effluent not originating from fuel is many orders of magnitude smaller than that removed with spent fuel. It arises from minor leakages of activated materials from the primary reactor system; its management is provided for in design and operating requirements through such means as concentration in rags and resins, retention to allow decay, or dilution to insignificance when appropriate.

e) The thermal energy conversion cycle is identical to that of fossil-fuelled thermal power plants, and the waste heat to be rejected is identical in quality and of the same order of magnitude for fossil-fuel and nuclear stations.

Capital costs. It is possible that reactors of the future could have very low capital costs. If this were achieved, it would be the result of achieving very high power density in a reactor of very large thermal rating. However, none of the reactor types now existing or under development are expected to reach the sort of performance which would result in real capital-cost economy. The most probable outcome is

that reactors will always be more expensive to build than gas- or oil-fired power plants.

The basic reason for extra capital cost is that reactors require a variety of auxiliary systems to be operated safely—systems which have no counterpart in fossil-fuel generation. These include: radiation monitoring systems in the plant; fuel failure detection systems in the reactor itself; coolant maintenance and clean-up systems; radioactive effluent decay, packaging or dilution systems; control rod systems which are elaborate electronic and mechanical complexes; and sophisticated instrumentation, which may include a process computer. In addition, concern for public safety has made conventional the inclusion of secondary containment or its engineered equivalent in building design, and led to several kinds of extra safety margins. Finally, nuclear fuelling involves special handling mechanisms, including (as required) heavy shielded transfer vessels, and decay storage pools for spent fuel. These systems all cost money. At this time, it seems that the decision to build a nuclear power plant involves a decision to spend $25 to $50 million on these components, the amount increasing only slowly with power. The remainder of the plant, on the other hand, is (and costs) the same as an oil-fired station of equal efficiency. This is a difference in capital cost which is overridden by fuel economies only in very large size units, or by highly favorable capital charges.

In the future, a mature industry would be expected to reduce this differential to $25 million for all sizes of plant. This amounts to $50/kw for a 500 MW plant, or $25/kw for a 1,000 MW system. It has been our experience that, except for extra items such as the heavy-water in a D_2O reactor, the capital costs of all reactors tend to be about the same; and we therefore expect in the future that sodium-cooled fast reactors would achieve similar costs to current BWR, PWR or AGR types, while HTGR types might have somewhat higher costs. (See descriptions below.) As noted, a good deal of the incremental capital cost of nuclear power is due to the inclusion of safety systems: there is no expectation that these systems will be skimped in the future. Indeed, our experience to date has been that we have been able to design greater safety to more stringent requirements at decreasing cost, up to now; so that we in the nuclear design business feel that any reasonable tightening of safety regulations can be met, by good engineering design, at little or no increased cost. Many fossil-fuel systems, on the other hand, are now being confronted with extensive modification to cope with pollution-control requirements of a type not foreseen originally. In a word, greater control can be achieved at modest cost to ensure decreased environmental stress from nuclear power plants, precisely because decreased environmental stress has always been a target of nuclear power plant design.

Just to complete the picture, it appears that coal-fired power stations are also more expensive than oil- or gas-fired ones, by about $25/kw. Thus, except for regions where coal is very cheap, and where mine-mouth power plants are feasible, we do not expect coal usage to expand greatly. Table 2 gives an estimate—subjective as to the future and "typical" for the present—of the capital costs of various types of power plant.

Table 2: Typical Unit Capital Costs of Various Types of Power Station

(Prices in $/kw, 1970 U.S. dollars; includes indirect costs, but not first core)

Type	1970		1985	
	500 MW	1000 MW	500 MW	1000 MW
Oil-fired	140	115	140	115
Coal-fired	165	140	165	140
PWR or BWR or AGR	190	150	180	140
HWR (CANDU)	260	220	250	210
Fast, Na-cooled	-	-	180	140
HTGR	-	-	190	150
Advanced HWR		-	215	175

Reactor Types

We present here a few words on the characteristics of reactor types which can be expected to play some part in the nuclear market penetration. The fact that there are many potentially valuable systems is a generally favorable aspect for nuclear energy, increasing the likelihood that at least one of them will meet or surpass performance or cost targets now set for them. Among any group of nuclear engineers there will be found enthusiasts for particular reactor types, who will argue strongly for their favorite systems. The classification of reactors which follows is my personal responsibility and betrays my personal prejudices rather than any world consenus.

Currently popular reactors. Boiling-water reactors (BWR) are pressure-vessel reactors fuelled with slightly enriched uranium, in the form of uranium dioxide pellets or cylinders jacketed in a zirconium alloy. They are thermal reactors, moderated and cooled with ordinary ("light") water. The heat is extracted by allowing the water to boil as it passes through the core, and the steam is passed directly to the turbine of the energy conversion cycle. BWR shares with PWR (see below) the feature of having the lowest capital costs of currently available reactors.

Pressurized-water reactors (PWR) differ from BWRs in that the primary reactor vessel is operated at considerable overpressure, suppressing boiling of the cooling water. Heat is then transferred to steam in a separate steam generator. By suppressing boiling, some improvement of heat transfer is achieved and the power density of a PWR is greater than that of a BWR. Costs, cycle efficiencies and total plant sizes are very similar for the two types, even though fuel design and fuel management are somewhat different, and there is keen commercial competition between them.

Advanced gas-cooled, graphite moderated reactors (AGR), are reactors constructed using a graphite lattice as major moderating material. Fuel is UO_2; cooling is done by carbon dioxide; the system can support a relatively high temperature, and the power conversion cycle is 40 percent or higher in efficiency. AGR was originally designed for the specific economic situation of the United Kingdom, and has so far won very limited acceptance in other countries. Its capital cost is somewhat higher than that of light water reactors, and its fuel cycle costs are very similar.

Pressure tube heavy-water reactors (CANDU): there are a variety of reactors moderated with heavy-water available from suppliers now; the largest capacity of orders has been registered for the type developed in Canada. The fuel is natural uranium oxide clad in zircalloy. The coolant is pressurized heavy water, whose heat is transferred to raise steam externally. The power cycle is that of a PWR. Its capital cost is higher than for light-water reactors, but its use of natural uranium fuel makes for generally low fuel-cycle costs.

Reactors on the immediate horizon. Organic-cooler HWR: major room for improvement of heavy-water reactors lies in the realm of thermal efficiency. Additionally, capital cost can be reduced by eliminating heavy water from the thermo-dynamic circuit. Both of these objectives can be achieved in principle by substitution of a high-boiling organic liquid for heavy-water cooling in a CANDU reactor. Such a reactor is now under development, and if successful there will be economic support for the already existing advantages of the heavy-water reactors.

Early breeders: currently available reactors use thermal neutrons and require a moderator. This is done to permit a relatively weakly enriched fuel to be used. If the moderator is removed, a much higher enrichment is required in order for the chain reaction to proceed. However, one gets from this change the ability to "breed," i. e., to produce more plutonium from fertile materials than is destroyed in the chain reaction. Many countries are engaged in reducing the basic fast breeder design concept to economic engineering

practice. Current performance targets are relatively modest compared with potentials and ultimate requirements. For example, it is likely that the plutonium in the fuel cycle will reproduce itself only after a relatively long period: most concepts with some near term feasibility have "doubling times" of 12-20 years, whereas world power demand will be doubling every 10 years for quite a while.

High temperature gas-cooled, graphite moderated reactors (HTGR): the AGR reactors are capable of development in two directions: still further increases in reactor and coolant temperature, and improvement in fuel cycle efficiency. Both of these developments rest on the substitution of helium for carbon dioxide as a coolant.

Reactors with promise for the long range future. The expectations for fast breeder reactors are very high. It is believed that with continued design improvements, not only in reactors but in reactor materials and in fuel fabrication and reprocessing, doubling times can be driven down toward 5-7 years, and temperatures raised to support advanced thermodynamic cycles (more than 50 percent efficiency). These aims may well depend on the development of uranium carbide as a fuel. They may ultimately be achieved separately, with some breeders concentrating on achieving very short doubling times, while others aim at high temperature. It would be imprudent to expect either of these aims to be achieved commercially within the next 20 years, however.

Advanced HTGR: the final realization of the aims of the HTGR program would be a reactor operating at such a high temperature as to be able to support progressively more advanced thermodynamic cycles of high efficiency. Helium cooling is compatible with high temperature gas turbine technology, and may be compatible with magnetohydrodynamic conversion. Coupled with this goal, and probably realizable, is the achievement of a high enough neutron conversion as to make this reactor almost a breeder. If realized, such HTGRs would complement high-gain fast breeders extremely well.

Molten salt reactors (MSR): under development, but with favorable results so far, is a high-temperature fluid-fuel reactor; the fuel vehicle is a molten mixture of uranium and other fluorides. It is possible to conceive of this reactor as a high-gain converter reactor, or as a breeder. If all problems of system and component design continue to develop favorably, this reactor could have a very interesting future.

Finally, fusion energy, often listed as a competitor to fission energy, is very unlikely to play a major role before 2000, owing to the very large engineering developments required to translate it into economic practice, assuming that the basic feasibility and design principles will be established—which they are not, at present.

Other Uses of Nuclear Energy

Other applications besides central-station electric power are contemplated for nuclear energy use in the future. These include: sea-water desalting by distillation; ship propulsion; remote base power; and space propulsion. All of them will require (and already are receiving) careful attention as to their environmental effects as their large-scale use materializes.

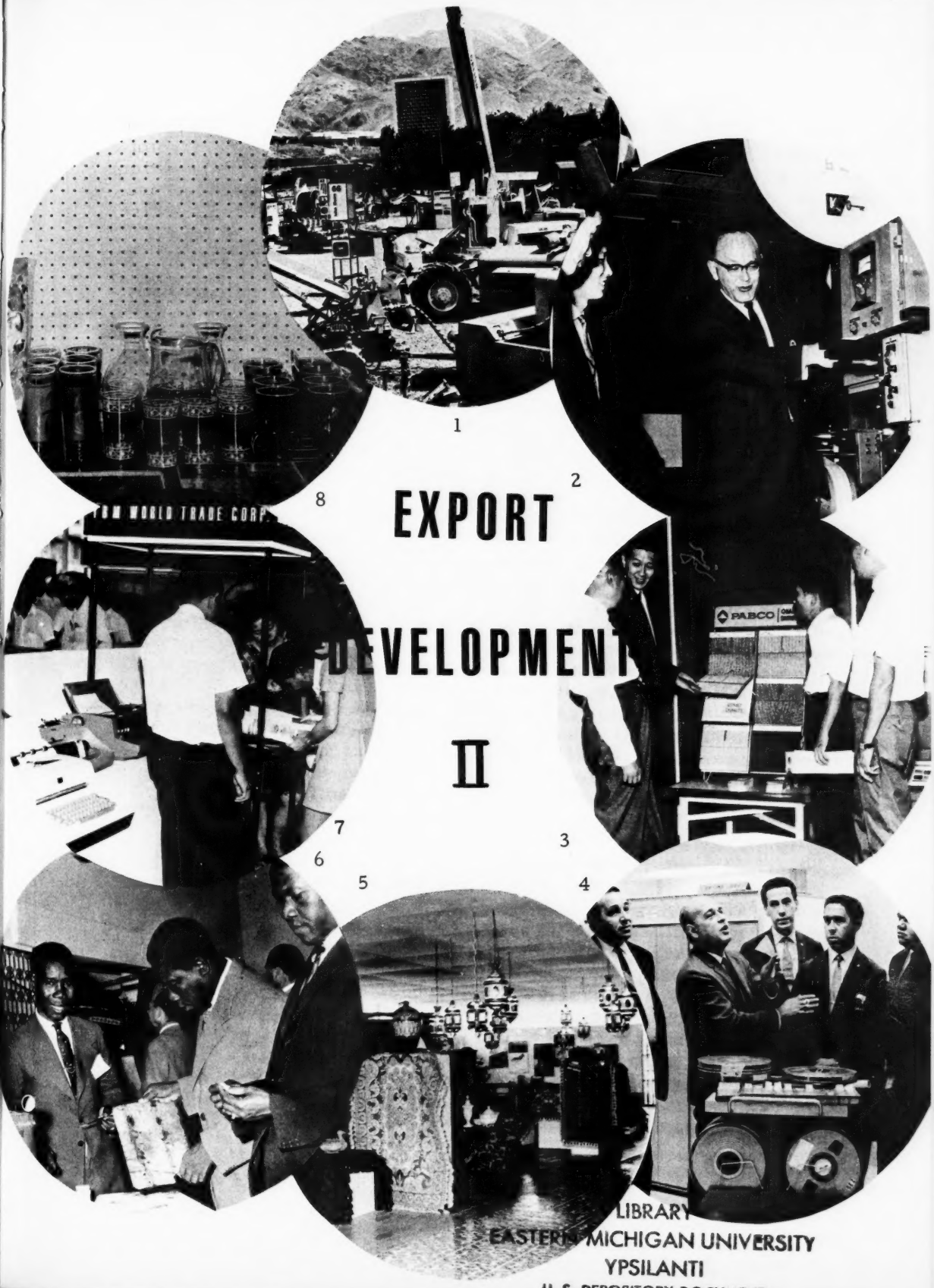
Sea-water desalting. A new application of atomic energy which is receiving careful study in the U. S., the USSR, U. K., Sweden, Mexico, Spain, Greece, Chile, UAR, Israel, Pakistan and other countries is the use of the heat from a reactor to prepare fresh water by distillation of sea water. Although it was originally conceived that this might be done as a single-purpose plant, it is now generally recognized that a cheaper water cost is achieved by constructing dual-purpose reactor plants, in which the thermodynamic potential of high temperature steam is used to generate electricity, while the lower quality heat (100-150° C) is used to distill sea water. A number of studies of the dual-purpose concept have indicated that when 10 to 30 percent of the reactor heat output is used to distill water, a broad minimum water cost exists. Therefore, relatively cheap distilled water supplies are associated with large central-station power plants. The price of the water, evaluated for systems which may be practicable in the next 15 years, seems, at best, to be within the incremental range of prices which a number of large cities and industries are now paying. If the price of desalted water can be driven well below 20¢/1,000 U. S. gal., and if agricultural research is productive, desalted water might also be useful in desert agriculture. One solution which is intriguing is to build an agricultural-industrial center at the site of the power-desalting plant; power would be used in light industries and in power-intensive industries such as fertilizer production.

Ship propulsion. As a result of the hazards to the public which may arise from accidents to the vehicles, it is unlikely that reactors will ever be used for automobiles, locomotives, civil aircraft or first-stage rockets. However, the endurance and compactness of the nuclear power source recommend its use for transport when the vehicle is large enough so that encapsulation and shut-down of the reactor can be ensured in case of accident. This is the case with large ships. A special purpose ship, such as the Soviet icebreaker Lenin, is a good example of the proper use of nuclear power for propulsion. An icebreaker must, by its mission, stay on duty for long periods without an assured refuelling supply; it must have plenty of power, and it must be rugged. Nuclear power also has the potential to make submarine shipping more feasible. There are reasons for submarine shipping to be more convenient than surface shipping, including the absence of wave action and the availability of such

routes as the Arctic Sea (under the ice), e.g., for hauling Alaska oil. More conventional ship propulsion does not appear to be an economical application of atomic energy unless special missions or conditions are encountered. However, the same economic laws which improve the competitive position of nuclear power stations in large sizes also work with ships; and vessels of several hundred thousand tons displacement, such as supertankers and cargo ships, are very promising for nuclear application. The cruising range of a reactor-powered ship is far greater than that of a conventional vessel with fuel, so that nuclear power offers the advantage of minimal port time for refuelling.

Remote bases, space applications. The same reasons as justify such nuclear applications as icebreaker ship power also justify the provision of nuclear power for such remote places as Antarctic or Himalayan exploration and scientific stations. Another possibility is that there will be incentives to establish sea-floor bases for mining, communications, fish herding, etc. In addition, there are potential space-bases for which nuclear power might offer weight advantages over its main competitor (solar power), when primary energy source, collector and energy storage and conditioning equipment are included. (For example, a moon base would need a month's worth of energy storage if operated on solar power.) A final possibility is the use of nuclear power for space propulsion. The savings in launch weight or increases in payload are so dramatic that it is a pity that nuclear space propulsion has not received a higher development priority, but the application is sure to come eventually.

[Excerpted from Environmental Aspects of Nuclear Power Stations. Vienna: International Atomic Energy Agency, 1971, Document No. STI/PUB/261, pp. 57-78. Proceedings of a Symposium held by the IAEA in cooperation with the U. S. Atomic Energy Commission in New York, 10-14 August, 1970.]



EXHIBITS AT INTERNATIONAL TRADE FAIRS.
[PHOTOS: U. S. DEPARTMENT OF COMMERCE.]

1. IRAN
2. JAPAN
3. THAILAND
4. BRAZIL
5. EL SALVADOR
6. TOGO
7. THAILAND
8. TOGO

Pinpointing Export Development

A. C. Banerjee

[TDA, a new agency of the Indian Government, was created to speed up exports by selecting particular firms and specific products with promising export potential, and then concentrating the necessary services and backing behind them to realize their potential quickly.]

After more than a decade of effort in export promotion, we in the Indian Government have realized that traditional, generalized trade promotion techniques are not working well enough. So we are trying a new tack—what we call the "micro" or "pinpoint" approach. A new government agency identifies producers with export potential, finds the most promising markets for their products, helps them gear up their production if necessary, and then leads them through the marketing process and helps them overcome the obstacles that stand in the way of actually selling to these markets. Although the size and complexity of India's export promotion institutions make its situation somewhat unique, many of the problems that led up to this new venture will be familiar to export promotion officials—and exporters—in other countries, and if it is successful, it may spur them to rethink their own programs.

Export growth is vital to the fulfillment of India's development goals, and in recent years it has made some substantial export gains with increases of 13.5 percent in 1968/69 and 8.5 percent in 1970/71. While these trends are heartening, our performance has not been good enough. Over the decade, the annual export growth averaged only 3.9 percent, compared with our current five-year goal of 7 percent a year. There

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has been an encouraging development in the nature of Indian exports: the share of non-traditional items such as ores, minerals and industrial products rose from 8.4 percent in 1960/61 to 35 percent in 1969/70, while the share of engineering products alone climbed from less than 1 percent to 15 percent. The share of North America and Western Europe in India's total exports has declined over the years, from 55 percent in 1960/61 to 39 percent in 1969/70. To increase our share in total world trade, it is imperative that we raise our exports to the affluent countries, particularly in manufactures.

There has certainly been no lack of attempts to promote Indian exports. Over the years the government has introduced a battery of incentives, and dozens of official, semi-official and unofficial institutions have been established to promote or service exports. But the procedures involved in taking advantage of the incentives have been so cumbersome and time consuming that many firms have been discouraged from even trying to export. And the effectiveness of the various export promotion institutions has been very mixed. One basic reason for the disappointing performance is that they have been too diffused and generalized. They have been based on general principles and devoted to commodities, territories and functions, but the exporter himself, the actor in the drama, has been in the background. So the thrust that would lead his product to his buyer was missing.

Birth of TDA

In January 1970, Mr. K. B. Lall, Secretary of Foreign Trade at that time, proposed the creation of an agency dedicated to exporters, a public sector agency that could operate autonomously outside the areas handled by state trading agencies, with the object of inducing and organizing mainly small- and medium-scale entrepreneurs to develop their individual export capabilities. It would bring within its umbrella integrated services to be rendered to the exporter at a single point. The idea quickly took root and grew. The Trade Development Authority is a registered society with its own charter; executive authority is vested in a Director, guided by a high-level Steering Committee whose Chairman is the Secretary of Foreign Trade. The TDA was officially registered in July 1970 and started functioning with a skeleton staff in September.

TDA has three divisions: Merchandising, Research and Analysis, and Information. The Merchandising Division is the core division, and performs TDA's field operations. It identifies export products and production units; helps its clients plan marketing strategy; puts them into contact with "the right" long-term buyers abroad; assists in product development and planning of capacity expansions; helps arrange production and shipment to meet the buyers' demands; and provides a single-point, package service for its clients, speeding up

administrative procedures connected with government licenses and incentives. The Research and Analysis Division conducts research into markets, products, production units and trade trends, while the Information Division collects and stores a wide variety of information on both the supply and demand side.

Micro Concept

What makes TDA distinct from most other export promotion agencies is its micro concept. What matters are particular products, not product lines or industries, and specific buyers, not just markets. TDA extends its services not to every Indian firm but only to those with real export potential, and it concentrates on the products and the markets with the greatest potential for India. Its approach is the identification of buyers in promising international markets, the quality requirements of these markets and the products that our industry can provide competitively. The next step is to render a package of personalized services to exporters at a single point, saving our clients a great deal of time, resources and plain annoyance.

Product areas. The criteria we used in selecting product areas were that they should involve a high proportion of value added by manufacture and be suitable to India's comparative advantages, such as low-cost skilled labor and available raw materials. In the initial three-month desk study we took account of existing and potential production and export capabilities, the existence of production units with the right attitudes to export, the long-term export growth prospects, the labor-intensive character of the product groups, and so on.

So far, TDA has selected 14 product groups with which to work, and we have been highly selective within these categories. So far, we have selected only about 100 specific products to work with within the first 13 product groups, and these are confined to a limited range of specifications. For example, the automobile parts category could include 100 components, but we have chosen to deal with only nine; from the entire range of handicrafts we have selected only two items—imitation jewelry and toys; of the broad range of canned fruit and juices manufactured in India, we have chosen only three—mango, pineapple and grapefruit.

For this limited list, there is substantial scope for developing exports. Current international trade in the product range has been estimated at $3.2 billion a year, mainly with the developed world. India's present exports of these products to the target markets (the United States, Canada, Western Europe and Japan) are only $8.5 million, and they are confined only to a very limited range of specifications and to a few Indian companies. Prospects for these items

in the target markets are very bright, and we feel it is possible to realize a minimum value of $71.4 million a year of these exports in the course of the next three years. To achieve this, present export lines will have to be broadened, and many new items hitherto not exported to the developed countries would figure prominently.

Selecting clients. The selection of production units is critical in view of India's past experience, when efforts by export promotion agencies in our product and market sectors have yielded few results. The first step has to be to identify selectively competent and viable production units with export capabilities and export-conscious managements and to assess their inherent or potential capacities for export. With the assistance of our consultants, Industrial Development Services, we have surveyed all the production units in our product range, with the exception of the woolen knitwear, imitation jewelry and woodwork sectors. Our object is to select as our clients only technically competent and commercially viable production units. Broadly, the technical criteria include the technical adequacy of production and processing equipment, tooling, shop procedures, inspection procedures within the plant, quality control, etc. The commercial criteria would include the export performance of the units in the past, the dynamism they show in handling foreign inquiries, the willingness displayed in adapting production processes and tooling to suit overseas buyers' requirements, and conformity to well-defined codes of conduct in internal and international trading.

So far, about 200 units have been enrolled as TDA clients, and more are under investigation. As TDA is only a service agency, there is no contractual relationship between the agency and its clients. They can avail themselves of TDA's entire package of services, or only some of them. It is important to underline that these services are confined to the units enrolled with TDA. If requests come from other firms, or concerning products not within our range, we do not turn them away but guide them as to how and where they can find help from other agencies.

Product development. The advanced markets of the world cannot be cultivated without preparatory product development. Therefore we have been encouraging our clients to move in this direction, getting them to import samples, drawings and technical literature from abroad and to prepare counter-samples for the approval of foreign buyers, and we have been studying product and packaging specifications in depth. Examples of this work include product development for the export of automobile parts, and of castings for pumps, machine tools and automobiles for the United States, the United Kingdom and Western Europe; bicycle components for Japan; electronic components for the Federal Republic of Germany; industrial fasteners for the U.S.; and container corner castings for Western Europe

and the U.S. Orders for these products totaling $780,000 have already been received. Should this field work succeed, the way will have been paved for an annual contracting for exports of at least $10 million a year on a long-term and sustained basis.

TDA is also deeply involved in a project of the UN Industrial Development Organization concerning product adaptation and development for export-oriented industries. The first step of this project involved identifying products that have a market potential in the United States, and the design changes necessary to meet the market's requirements. In the second phase, also completed, TDA prepared files on about 100 individual Indian manufacturers falling into 20 commodity groups, giving full details. The third phase, now underway, consists of advising the selected manufacturers on design changes and adaptation and on feedback from potential American buyers.

New capacity. One of the major constraints in the long-term promotion of exports of TDA's products is the inadequacy of manufacturing capacity in India. In an attempt to build sizable surpluses in its product range, TDA has initiated with government authorities a series of export-oriented proposals in electronics, bicycles and bicycle components, thermosetting and thermoplastics, designed to yield an export of $28.5 million a year. On behalf of our clients we have already piloted six export-oriented production projects through the government's Industrial Licensing and Capital Goods Committees and won approval for them. They are in the fields of automobile ancillaries, electronic components, bicycle components and hand tools. The estimated annual export yield from these undertakings is $5.7 million.

Besides speeding the way for projects initiated by its clients, TDA is actively initiating projects to be taken up by the client firms. We have won approval for a project to produce 300,000 sewing machines, as well as components, with 60 percent export orientation; foreign participation in this project will amount to 40 percent. Another major project that has won approval is for production of a half-million multi-speed bicycle hubs and coaster brakes, of which 75 percent is earmarked for export.

In a bid to remove capacity constraints on a few of TDA's products for which export opportunities have recently opened up, we have undertaken preparation of six pre-investment feasibility studies and project reports. They concern components for special models of bicycles, plastic moulds and dies and mouldings and extrusions, mini-motors for toys, and printed circuits and other electronic components. The preparation of the actual project reports has been entrusted to experienced Indian technical consultancy firms, with an

American engineering consultant from the U.S. Agency for International Development (AID) to coordinate the project. After all the reports are out (by March 1972), suitable entrepreneurs are to be selected to implement the projects.

Subcontracting. It has been felt for some time that India is not cashing in on the large volume of international subcontracting opportunities offered by firms in industrialized countries for parts, components and accessories. Because of rising wages and labor shortages, companies in the industrialized countries have been turning to suppliers in developing countries. Taiwan, the Republic of Korea, Singapore and Hong Kong have been getting most of this business. But there is no reason why India should not win a bigger share, and TDA has taken the lead in a major project designed to do just that. In conjunction with a government-recognized export house and several manufacturers, TDA is sponsoring development of a customs-bonded processing and warehousing facility for the export of electronic assemblies, subassemblies and components. The project will be located at Santa Cruz Airport, Bombay, and will be totally export-oriented. The raw materials would be air freighted in, and the output would be exported by the same means, generating a projected $3.5 million a year in net foreign exchange earnings. A 100-acre site has been acquired for the project.

Speeding licenses. Companies developing products or actually engaged in production for export are almost always faced with the need to import a variety of materials: technical samples and literature, capital equipment and raw materials. One of the barriers to promoting exports has been the long delays involved for firms trying to get licenses for such imports. TDA's Package Servicing Plan was designed to solve or at least reduce this problem. The agency has been granted a free foreign exchange allocation by the Ministry of Finance for product development by its clients. Under this arrangement, TDA clients find it easier to import samples, drawings, technical literature and specifications, as well as initial small lots of raw materials, components, consumables, tooling and test equipment for product development. The client now submits its application for such imports to TDA, which can get the license issued in the average of only one week.

Although it has no advance foreign exchange allocation for material and equipment needed for production arrangements and expansion, TDA can also speed up the licensing procedures. For example, the issuance of licenses for raw material and component imports normally takes four or five months. TDA has been able to cut this time lag to about one month for its clients, thanks to special arrangements with various government authorities.

Cultivating buyers. TDA's Merchandising Division has also been busy cultivating buyers, focusing our attack on the large department stores, wholesale importers and distributors and big industrial buyers in the target markets. We have been sending prospective buyers detailed information about our clients and their production potential, encouraging the clients themselves to send their technical and commercial representatives abroad to explore the market and locate buyers, and arranging for buyer delegations to come to India. As a result of the many contacts brought about by TDA, our clients have already concluded deals worth several million dollars with buyers in the U.K., West Germany and the U.S., for items ranging from stainless steel cutlery to electronic components. These represent new business—either in new products for existing markets or new markets for products already exported elsewhere.

Another important means of promoting buyer-seller contacts is through arranging visits to India of buyer delegations. We have already brought in two from Japan—one representing the plastics industry, the other from the sewing machine industry. The second delegation has placed trial orders for sewing machine components, and is currently studying TDA proposals for creating new capacity in India for components production. A delegation from Macy's, the huge U.S. department store group, is to come to India at TDA's request in October to discuss product adaptation to suit its needs for such items as ready-made garments and hand tools. And two delegations from the United Kingdom are coming this autumn to discuss subcontract production of automobile and electronic components and parts.

The Information Base

If they are to succeed with a reasonable degree of efficiency, exporters must have prompt and reliable answers to a multitude of questions. Many organizations in India are collecting and disseminating commercial and industrial information, but their activities and their output is not coordinated; nor does this mass of information always meet the specific needs of TDA or its clients. To solve this problem, TDA has set up a Trade Information Center. This ambitious project was launched with the assistance of a consultant supplied by AID. The International Trade Center of UNCTAD/GATT will also assist in developing the TDA Center, under a grant from the Swedish International Development Authority. The Center will not duplicate the activities of existing organizations but will collect and disseminate trade information in unexplored areas, besides coordinating the information already available.

Initially the Center has been drawing upon and supplementing the information available from existing export promotion organizations and various industry and trade associations, international organiza-

tions, and from government agencies and trade associations abroad. We have, for example, made arrangements with Japan's JETRO to exchange information and publications, train personnel and provide commercial intelligence to visiting business delegations from India. TDA is a member of the World Trade Centers Association, which will give us access to information from some 45 member Trade Centers. All the members of this system will use the same coding method to facilitate the interchange of information about where to locate many thousands of information sources. TDA hopes also to eventually have its own network of overseas correspondents.

Information system. We have already done a considerable amount of work in setting up the information system for our 14 product groups—a system designed to be extended to other products. Worldwide sources of information have been classified by commodity, by country and by subjects, with a system for easy cross reference. All documents are coded to be compatible with the information from other trade centers, so they can eventually be converted to mechanical or computerized operation. The information is stored on one of four types of cards: 1) Interfile cards indicating worldwide sources of information on various aspects of foreign trade. 2) Manufacturers cards made up on each TDA client. They show such information as products, capital investment, production capacity, production particulars, export performance, etc. 3) Product cards. For each item within the 14 product groups, these show total installed capacity in India, actual production, capacity obligated for export, planned licensed capacity likely to mature, global imports, potential markets, etc. 4) Product-country cards. There is a basic market intelligence card for each target market for each product. These cards are still being built up.

TDA's Information Division is also gathering a variety of other information. It has, for example, prepared over 150 design and specification sheets for more than 20 electronic components and pieces of equipment, relating to the products manufactured by leading producers in the United States. These should help in reorienting Indian production. We have also been building up information on packaging materials. And we have begun issuing a series of country-market information bulletins bringing together general market information on TDA's product groups, by country.

Research

The Research and Analysis Division is attempting to shed light in areas that will help guide India in its longer term export development efforts. The division is pursuing three main work areas: 1) Analysis of individual firms, with a view to evolving suitable policies and an optimum action mix. 2) Coordination of national export research activities. 3) Forecasting short and long-run export trends.

Analyzing firms is currently the division's core activity. It has set out to undertake detailed studies of production units in the selected product lines, going into their production costs, cost-benefit analysis, product ranking, exportability indices, and the selection and classification of competent units. The division has embarked on an inter-firm comparison project to product a set of norms, differentiated by groups of industries, product groups and size of firms. The norms basically relate to the efficiency of resource use, classified broadly into capital, manpower, raw materials and marketing costs. This project will attempt to study in detail the structure of production, operational pattern and financial ratios of the major exporting units as well as units that have the potential to export. With these norms we will be able to evaluate the export effort of the individual firms; assess the efficiency of the export production base; and suggest various types of assistance—technical, financial, marketing, etc.—needed by the exporting units in order to optimize their performance.

In the past a variety of organizations in India have undertaken a large number of surveys aimed at identifying export potential and strategies. While these studies have been useful in creating an awareness of India's vast export potential, follow-up action has been rather slow. The main reason for this has been the lack of involvement of the supposed end-users of this research in its planning and implementation. In short, we have invested a great deal in market surveys, but not enough in marketing research. TDA's Research and Analysis Division intends to build itself into an apex institution for programming, coordination and implementation of export research. It has already initiated action to put together a "National Research Performance Budget" on an annual and rolling basis. The main idea is to make export research end-use oriented, operational and specific. The division has already started coordinating surveys in progress. It now expects the various export promotion agencies to send it their market research requirements, which will be dovetailed into the Performance Budget.

[Excerpted from "TDA: Pinpointing Export Promotion," International Trade Forum. Geneva: International Trade Center, UNCTAD/GATT, Vol. VII, No. 3, July-September 1971, pp. 4-10 and 29.]

Handicrafts Marketing

International Trade Center,
UNCTAD/GATT, Geneva

[Export markets for handicraft products are promising but require increasing price competitiveness, and quality control in the products offered, along with timely and reliable deliveries in quantity—difficult for many craftsmen to achieve. Suggestions for new suppliers are offered.

Owing to the great variety of products traded under the name of handicrafts, the market is very complex. It may, nevertheless, be divided into two main sectors: handicraft articles of everyday use, offering export possibilities for developing countries able to supply such articles in volume; and "arti-crafts," the supply of which is small in volume and the marketing aspects of which differ from those of utility handicrafts. Handicraft articles of everyday use may be merely utility items such as salad servers or tea sets, decorative items such as wall-plates, and items of personal use, e.g., embroidered handkerchiefs, or of personal adornment, e.g., costume jewelry. Fundamental characteristics of the market for these items are that suppliers must be capable of delivering large quantities, and the articles must conform with a number of quality and price standards. The market for these products offers the most interesting prospects for developing countries desirous of increasing their export earnings, and is the main concern of the present survey. In all the countries we investigated, the demand for unusual articles of everyday use is increasing in step with a rising standard of living and the desire of consumers to embellish their prosaic everyday environment. It must be made clear, however, that this increased demand is directed not only towards handmade handicrafts but also towards machine-made goods as long as these meet with the requirements of the design-conscious consumers.

The eventual decision in favor of one or the other depends on quality and price, however. This is often to the advantage of mass-produced items, which can offer machine-made quality, low prices and, moreover, designs with a "handmade" appearance, e.g., "rustic" ceramic ware.

To distinguish these articles from handicraft items that are primarily of an artistic nature, the term "arti-crafts" might be used for the latter. However, the distinction is not a hard and fast one; close technical examination may be required to distinguish a genuine "arti-craft" from a similar article produced in quantity—e.g., an original wood carving made by an unknown African craftsman-artist in one or a very few copies, from the well known "African wood carvings" often produced (not necessarily in Africa) by highly mechanized processes and retailed by the thousands. Buyers' attitudes and tastes are also pertinent. For example, handmade wooden salad servers are sold as household articles in department stores when the motivation for their purchase may simply be the need for a new set of salad servers; on the other hand, comparable wooden salad servers may also be offered by small boutiques specializing in "exotic" articles of various types. Due to the nature of the articles, the market for "arti-crafts" is very small. The demand in consumer markets for these works from developing countries is increasing, however, particularly in the higher income brackets, in step with increasing international travel. It is one of the main concerns of the World Crafts Council in New York, an international organization affiliated with UNESCO, to further the sales of "arti-crafts" at the international level.

Size of International Trade

It is not possible to make a valid assessment of the volume of trade in handmade handicrafts. Firstly, statistics generally do not distinguish between handmade and machine-made goods; secondly, owing to the general practice of classifying these goods according to the raw materials used, it is often not possible to single out the articles in question. Costume jewelry, for example, is found under BTN heading 71.16 (imitation jewelry) if composed wholly or partly of base metal or of at least two non-precious metals, but also under BTN heading 44.27 (covering inter alia wooden standard lamps, bookends, cutlery boxes and bathroom cabinets), or under BTN heading 95.01 (worked tortoise-shell and articles thereof). [BTN, Brussels Tariff Nomenclature, is a standardized classification of products.] These facts should be kept in mind when examining Table 1, which attempts to show the relative importance of the six import markets surveyed for six product groups.

The major importer of these articles in Europe is the Federal Republic of Germany; in the world, the United States. Imports into

Table 1: Imports of Selected Product Groups of Export Interest to Developing Countries into Selected Countries in Europe and North America in 1970

(Values in thousand dollars)

		Switzerland	F.R. Germany	United Kingdom	Yugoslavia	United States	Canada
A.	Articles of wood	3,799 (344)[a]	9,129 (1,231)	4,399 (..)	65 (19)	40,084 (8,388)	
B.	Articles of plaiting materials	1,694 (198)	7,611 (2,381)	4,293[b] (..)	30 (-)	15,039 (4,209)	..
C.	Embroidered articles	1,274[c] (3)[c]	[d]	[d]	[d]	[d]	
D.	China and pottery	11,225 (22)	19,622 (-)	9,297 (..)	2,284 (22)	144,758 (1,973)	36,784[e] (1,180)[e]
E.	Imitation jewellery	7,855 (192)	6,009 (244)	6,957 (..)	273 (1)	24,466 (2,143)	7,798 (177)
F.	Articles of animal and vegetable carving materials	217 (10)	4,275 (119)	406[b] (..)	43 (6)	4,974 (442)	.. (..)
	TOTAL	26,064 (769)	46,646 (3,975)	25,352 (..)	2,695 (48)	229,321 (17,155)	59,108[f] (2,009)[f]

Source: National trade statistics

[a] The figures in parentheses denote values of imports from developing countries

[b] Figures are for 1969

[c] Embroidered household linen only

[d] Not available separately

[e] Including art and decorative ware of materials other than china and pottery but excluding that of glass

[f] Except in the case of china and pottery and costume jewellery a breakdown of the selected articles by materials is not available.

Yugoslavia are comparatively small, in fact it is one of the principal handicraft exporters. The share of imports from developing countries is as yet very small. It is highest in West Germany (8.5 percent of the total import values in the selected product groups) and the United States (7.5 percent). The major suppliers in this group are India, the Philippines, Taiwan, the Republic of Korea, Thailand, Mexico

and Yugoslavia. The product groups most successfully exported are articles of plaiting materials and of wood, i.e., articles the production of which requires a considerable amount of handwork (the use of plaiting machines is limited to certain types of materials which can be worked into continuous fibers) and those made of materials not commonly found in the consumer countries (e.g., palm leaf, teak, etc.).

Design, Presentation and Quality

Careful and well-conceived design, especially in the utility sector, is essential. It presupposes due assessment, on the one hand, of the limitations imposed by the availability and costs of the raw materials, and the degree of skill of the craftsmen and, on the other hand, of the needs of buyers and consumers. The best policy is to select materials domestically available at low prices, which may or may not be those traditionally used by craftsmen; in many developing countries there is an abundance of raw materials, often by-products of traditional manufactures or agricultural production, which often tend to be overlooked. The requirements of the buyer and consumer are many. In the first place, the article must be suitable for a particular end-use in a particular market; the requirements regarding measurements, finish and form may vary from one country to another (e.g., salt-shakers have five holes in continental Europe as against one hole only in the United Kingdom). The article must also meet the consumer's aesthetic taste. There is a general demand for new designs of everyday utility items; the two main fashion trends today may be described as "modern colorful" and "rustic." The first favors strong, vivid colors, straight, simple lines and abstract decorative motifs. The second favors a natural finish, rustic but stylized forms and decorative motifs. "Exotic" articles, from countries which are still little known to most consumers in the countries surveyed, must have a genuine local flavor, an individuality representative of the style of the country of origin. However, interest in "tourist" items, in which the local flavor is overdone and which tend to resemble each other, is rapidly declining. Another point to consider is the need for periodically renewing the design of products to avoid saturation of the market, with a consequent decline in demand—as was experienced, for example, with Indian brassware.

Articles should be designed to permit space-saving packaging for overseas shipment. Basketware, wooden items and ceramics tend to be bulky, and the high freight rates resulting from uneconomical packaging discourage import orders. Furthermore, buyers for import houses or central buying organizations, unlike tourists, need to be presented with a well-balanced assortment of items from which to choose, in turn, the assortment they intend to present to their customers. Any given item should be presented in some five or six

different forms as regards size, color, design, decoration, etc. Product design and presentation are often discussed between buyers and producers. Occasionally buyers provide their own designs and require an item to be made according to their specifications. Where business relations are well established, importing firms sometimes delegate one of their designers, on a temporary basis, to the producer to set up a local design unit. Newcomers, however, would be well advised to establish such a design unit from the outset, in spite of the additional costs involved, and not to leave design and presentation to the judgment of individual craftsmen. Such a design unit must, of course, be familiar with popular designs in the import markets, either through cooperation with buyers or designers in such markets or through magazines which reflect current fashion trends.

The quality of the products is decisive for their eventual success or failure in the market. Traders we interviewed usually stressed that handmade products were expected to be at least equal in quality to similar machine-made items. This does not mean that, for example, in the case of a rustic coffee set with a "running glaze," each cup must look exactly the same; however, all the cups in a shipment must be of exactly the same size, the same basic color(s), and have an even base and a perfect finish; this also applies to subsequent shipments. Items, for instance, which come into direct contact with food must conform with certain standards of hygiene; toys must conform with safety standards. Traders complained about difficulties with suppliers from developing countries which eventually resulted in termination of business relations. Examples mentioned were: ceramic mugs made with lead galzes dangerous to health, shopping bags where dyes ran off in the rain, children's toys with protruding nails, or wooden chairs made from uncured wood which rendered the chairs unusable once the wood had dried. Producers or exporters should, therefore, consider setting up an efficient quality control unit. Wherever necessary, certificates from an official body attesting the required quality (e.g., the absence of lead in the glazing of ceramic beverage mugs) should be provided.

Price Aspects

Price is a decisive factor in the marketing of handmade handicrafts, particularly in the utility sector, though less important in marketing decorative articles. Consumers are very price-conscious and, while generally appreciating handmade goods as a welcome substitute for standardized, machine-made items they will carefully compare their prices. It is generally accepted that prices of handmade articles are somewhat higher than those of similar mass-produced items, but it is also expected that they should remain within a reasonable range. It is worth noting that the markets we surveyed are at present supplied by exporters in a number of countries in the Far East and East-

ern Europe who offer extremely competitive prices. Importers and buyers for central buying organizations tend to expect newcomers to offer prices 20 percent lower than those for familiar products of similar design and quality before envisaging a change in their supply sources.

In calculating his export f.o.b. price, a producer or exporter has to take account of all charges, taxes, mark-ups, etc., which enter into the ultimate retail price of his product in the import market. The retail price is normally between three and four, and sometimes five, times the f.o.b. price. In very rough terms, the ocean freight and insurance add 25-35 percent to the f.o.b. price, and handling charges, import duties and inland transport add another 25-45 percent. Retailers' taxes and mark-ups are generally 75-120 percent over wholesale prices. Greatest variations are found in the stage or stages between initial importer and final retailer, depending on how many transactions intervene, and what taxes and storage or other costs must be covered. Importers and buyers for central buying organizations generally prefer c.i.f. quotations for the easier calculation of their prices, but freight charges may vary greatly from one shipment to another if the exporter cannot reach a firm agreement with a shipping line. By stipulating c.i.f. prices, the buyer obliges the exporter to arrange for stable shipping terms or take the risk of changes.

A principal component in the export price is the cost of the necessary raw materials. It is strongly recommended that only domestic raw materials be used, and that any imported materials which unnecessarily increase production costs be avoided as far as possible. While labor costs in developing countries are normally low, they may gradually rise as newly established industries offer higher wages. In such cases it may be necessary to introduce a degree of mechanization in handicraft production, not only to reduce expensive labor but also to improve the image of the handicraft industry in the eyes of the labor force. Various types of machinery are now available, such as plaiting machines for the most labor-intensive aspects of the production of certain plaited articles, or multiple-head copying lathes for the simultaneous production of certain wood items. In this connection, it would be advisable to seek the cooperation and assistance of UNIDO (United Nations Industrial Development Organization) through the governments of the countries concerned.

Because of the often relatively high trade margins, an exporter may feel that it might be more advantageous for him to approach central buying organizations for department stores which buy in large quantities and generally work with lower margins than are customary in distribution through importers/distributors. It should be borne in mind, however, that these central buying organizations

have to buy with prices as their prime consideration if they want to keep expenses down as much as possible. Importers/distributors, by contrast, owing to the diversity of their customers, have comparatively good possibilities for placing higher priced items and can also take the time needed to test the market for new products. It may therefore be advisable to approach a new market through such importers—mostly long established and specialized—in spite of the relatively high margins at this level of trade.

Purchasing Methods and Commercial Practices

Buyers for import houses and central buying organizations, who usually specialize in one or more groups of the articles surveyed, make purchasing trips at least once a year to the most important countries of origin. These trips are mainly limited to Western Europe and several countries in Asia—India, the Republic of Korea, Hong Kong, China, Taiwan, Japan, the Philippines and Thailand—where the firms have long established business connections. On their visits these buyers meet mainly traditional producers and exporters, but may also—deliberately or by chance—establish new contacts. While suppliers in other countries in the same area or in the countries which are on the itinerary to the buyer's final destination have a fair chance of being visited, the prospects for those from other areas are relatively low since round-the-world trips are very rare. This is due not only to the high expenses involved in such trips—even for larger firms—but also because the buyers' knowledge of production in non-traditional supplying countries is generally limited. In addition, many buyers are not particularly interested in new supply sources since their requirements are more than satisfied by the present suppliers.

In Europe, buyers for central buying organizations, including those from North America, regularly visit the big international fairs at Frankfurt-am-Main, Cologne, Milan, Blackpool, etc., in search of novelties to complete their assortments. The most important are the spring and autumn fairs in Frankfurt, and the Blackpool fair which specializes in giftware. For the North American buyers, the gift shows in the ten major cities are of equal importance (New York, Chicago, Philadelphia, Dallas, Los Angeles, San Francisco, Boston, Washington; and Montreal, Toronto). The main orders are made in early spring (February-March) for the Christmas sales season and in late autumn (October-November) for the summer (i.e., tourist) sales season. Extensive purchasing trips are normally outside the possibilities of specialized retailers, who chiefly rely on sample shows organized by specialized importers/distributors and manufacturers or by the latter's traveling salesmen and, of course, on samples exhibited at the big fairs.

Importers and central buying organizations usually reckon on delivery times of between two and six months from the date of order for merchandise from overseas countries. It is vitally important for exporters to keep strictly to the contracted dates of delivery, as merchandise which arrives too late, e.g., for the Christmas sales, may remain unsold, and the exporter will gain the reputation of being unreliable and may not get repeat orders. Quotations are generally preferred in hard currency c.i.f. the nearest port. Regarding payment terms, preference was often stated for cash payment against documents, or occasionally upon receipt of the merchandise; the letter of credit appears to be less favored by traders. All purchases are made upon prior examination of samples, which must truly represent the merchandise offered; particular attention should be paid to the labeling of samples. Samples may be supplemented by catalogues, or by color photographs plus comprehensive information on color codes, sizes, materials used, etc. Increasingly sophisticated catalogues are coming into use; unless exporters in developing countries can produce catalogues in accordance with the latest standards, they should rather supply good photographs, which serve the purpose as well or better.

Tolerances in regard to quality and quantity of the merchandise are very strict. Particular attention must therefore be paid to the accurate execution of an order. Craftsmen, while skilled in their particular work, are often ignorant of the particularized requirements of the consumers of their products and do not realize that apparently small variations in execution, e.g., in size or color, may render an item unsalable in the target market. Handicraft production is often fragmented, with small producing units scattered throughout a country. Many of these units producing exportable items may not have the necessary experience of export procedures; importers seem generally reluctant to deal directly with such producers, and it is recommended that they seek the cooperation of an export agent who can provide the necessary services. A number of the items surveyed, especially those which are subject to frequent fashion changes like costume jewelry, necessitate efficient communication between the trade partners. This has been found of great importance to various traders we interviewed, and cases were reported where, owing to a lack of readiness to communicate or to discuss problems arising out of business relations, such relations were discontinued.

How to Approach a New Market

Importers are generally not very responsive to written offers, because they find that various important points which are fundamental for an eventual diversification of their supply sources cannot be sufficiently treated by correspondence. They expect exporters to es-

tablish personal contacts and to furnish comprehensive information on the products offered (samples, catalogues, etc.), present and future supply potential, financial background, earlier export experience, packaging methods, shipping arrangements and delivery times. Exporters or their representatives should be in a position to discuss price changes in the event of eventual modifications of items offered. Except where buyers can be easily contacted during their regular purchasing trips to certain countries, it will be necessary for exporters in other areas to send a representative on a sales tour to the major importers and central buying organizations preceded by letters of introduction. It is normally recommended that the initial approach be made to specialized importers rather than to central buying organizations, because of the wider possibilities offered. The clients of importers, many of whom are also distributors, are very varied and include, in certain product lines, the central buying organizations.

One of the most favorable occasions for this approach is the participation in an international fair; experience shows that at least three consecutive participations are required. Here, a newcomer may not only attempt to attract clients directly but may also establish valuable contacts with importers who exhibit at the same time. Although the costs of participation in a trade fair may be high for newcomers, particularly since results may not be achieved until after several participations, such an investment is strongly recommended. Fair managements usually provide possibilities for extensive and directed publicity, e.g., through special inclusion in the official fair catalogue, assistance in the organization of press conferences, etc., which help newcomers to establish contacts with the right traders. (Cases are known where developing countries were quite successful in securing orders during a trade fair but were then unable to meet the required delivery times, and consequently lost many clients.) Developed countries often facilitate the participation of developing countries in trade fairs—e.g., by granting subsidies for this purpose.

It seems advisable to offer an established importer/distributor the exclusive agency for the products concerned as this will be a particular incentive for the importer, i.e., the assurance that he is the only domestic supplier of a given product. Some countries have successfully penetrated the market by supplying merchandise, mostly fashion items, on a commission basis to importers/distributors and central buying organizations: upon termination of the particular sales promotion unsold merchandise was taken back. Such a possibility should not be neglected in discussions with potential trade partners. Several countries supplying handmade handicrafts have established their own retail outlets in target markets which import directly, or they have appointed representatives for the same pur-

pose. This is usually done in cooperation with national tourist boards or government export organizations and covers only a limited range of "exotic" or "tourist" items. If such an operation is intended to handle volume sales, however, it is recommended only for developing countries with considerable financial resources permitting establishment of the services normally provided by local importers, distributors and retailers.

[Excerpted from Handicrafts Marketing. Geneva: International Trade Center, UNCTAD/GATT, 1971, pp. 2-24.]

Right: Batik fabrics, Indonesia. [Photo: International Labor Office.]

Above: Traditional designs applied to tourist items. [Photo: United Nations.]

Right: Craftsmen hand decorate pottery, Pakistan. [Photo: World Bank.]

Know Your Markets

[A number of business executives and other experts in international trade have contributed statements concerning particular markets or market segments that could be of assistance to potential exporters in developing countries who wish to enter or to increase their sales in these markets. The introduction to these excerpted statements summarizes some common themes.]

Introduction

All contributors emphasized the importance of carefully studying the particular requirements of buyers and consumers in the markets in question, and of matching one's offerings of products and the manner of their presentation to these requirements. Strong competition in both price and quality must be recognized; performance below competitive standards will jeopardize sales prospects. Much of the advice given in the preceding article on handicraft marketing applies as well in other fields. Nevertheless, the possibilities of gaining a foothold in expanding international markets are real enough if the exporter can understand the requirements and adapt to them, and if he can seek out and persuade the appropriate buyers. In this connection, an acquaintance with the structure of markets—the different kinds of buyers, their location and identity, and their purchasing methods—can be of great help in guiding the exporter's sales efforts to focus on the most promising buyers without a costly search or a wrongly-timed approach.

Four of these statements deal with general consumer goods marketing in the U.S., Europe, or Latin America. One covers furniture; two concern fresh fruit and vegetable products from the producer's side and from the buyer's side.

I. Consumer Goods (U.S. market): Edward Ackerman, R. H. Macy and Co., Inc., Department Store, New York.

To the manufacturer or distributor unfamiliar with the U.S., the size, geographical spread, and complexity of this market would make it appear to be a most difficult one to penetrate. Fortunately, it is not necessary to travel the breadth of the land to make the contacts necessary to introduce one's products; a majority of the purchasing agencies for retail establishments are found in a few major marketing centers. The foremost of these, as might be assumed, is New York City—headquarters for management and purchasing functions of the giant chain stores, department store groups, wholesalers, and buying offices servicing independent department and specialty stores throughout the country. Chicago, Los Angeles and Dallas are regional marketing centers of importance in special merchandising areas. Chicago is especially famous for its National Homewares and recreational goods shows, and its central location also makes it important as a meeting place for merchandising conventions for a wide variety of goods. Dallas and Los Angeles merit special attention as clothing centers, with Los Angeles particularly noted as the buying center for "California Fashions" in men's, women's and children's wear. Dallas is also important as a general merchandise wholesale market for the southwestern area of the U.S.

Apparel Mart, Dallas, Texas.

For the manufacturer or distributor attempting to gain a first foothold in the U.S. market, the very many buying agencies present in New York make it possible to explore the entire spectrum of the retail market without leaving the city. Assuming that one has a product that is useful or decorative, is well made, attractive in design and competitively priced, there are many opportunities to present it to potential buyers. For example, if the product is available in large quantities, major chain or department store offices like the following might be interested: Sears Roebuck, J. C. Penny, Montgomery Ward, Allied Purchasing Corporation, Associated Merchandising Corporation, Associated Dry Goods Corporation, Interstate Department Stores, R. H. Macy & Co. (Corporate Buying Division), May Company Department Stores. The "Resident Buyers" section in the yellow pages of the New York Man-

hattan telephone directory also lists several hundred buying offices which service a variety of smaller department and specialty stores. Merchandise of special interest to boutiques should be referred to the headquarters of "National Boutiques and Shows," Hotel McAlpin, 34th Street and Broadway for advice. The Giftwares and Decorative Homewares accessories wholesale market in New York is centered at 225 Fifth Avenue, and inquiries concerning those categories should be directed to the Buyers Information Service at that address.

II. Consumer Goods (U.S. market): Frank M. Racine, Sears, Roebuck and Co., nationwide (and international) chain of general retail stores.

Today the buyers for large retail chains and department stores have developed precise methods; no longer do they play hunches or follow whims. The tools of their trade are statistics, compiled from sales histories which reflect turnover, margin of profit, seasonability, etc. Concomitant with this trend, the vendor's role has also, by necessity, become more sophisticated. To meet with a buyer and present an attractive product is merely the first step; before he signs an order, he will have a hundred questions to be answered, ranging all the way from production capacity to shipping costs to packaging. The seller must anticipate this barrage of questions and have answers prepared in advance. The interest span of a busy buyer becomes distressingly short when answers to his questions are not forthcoming; usually he is already buying a product similar to the one being offered.

Another area which must be given serious attention is market research. A great merchant once said, "Marketing is listening." In the final analysis, it is, after all, the customer who dictates wants, trends and tastes in consumer goods, and one must go into the marketplace to "listen." The benefits of being flexible enough to fit one's product to the market then become apparent. Often this means no more than some slight "tailoring;" more infrequently, a major alteration is called for. But sometimes a product which is manufactured and which enjoys phenomenal sales in one country may have no market potential whatever in the United States or Europe. None of this is intended to discourage anyone from going after their share of the potentially profitable export market. Rather, it is an attempt to indicate the cold reality of the pitfalls to be avoided in developing an export business.

III. Consumer Goods (European market): Andre S. de Zagon, Director of Buying Office for the R. H. Macy-May chain of stores, Brussels.

In establishing practical general guidelines for successfully marketing goods on the European market, one has to be aware that conditions vary considerably from country to country, and the problems

will differ with individual products. Generally speaking the European market is more difficult to penetrate in terms of commercial information than the U.S. market, as the distribution patterns are usually more complicated and information is not readily volunteered. The Commission of the European Economic Community (EEC) has recently published a study on: "The Commercial Promotion of the Products from the Association of African and Malagasy States on the Markets of the Member States of the EEC." It analyzes selected products and the problems of marketing them, and proposes solutions and approaches the better management and marketing organization. It is more or less geared to action at government levels and for broad categories of products, but its approach is basically practical and its conclusions applicable to individual exporter's problems.

Gathering information is the first step for an exporter considering the European market. Two categories of information are important: a) Technical—government regulations concerning import, licensing, labeling, packaging, quota regulations, duties, etc. in the countries of interest. This information is usually available from Commercial officials in the Embassy or Consulate of each country or from Chambers of Commerce. b) Commercial Information—depending on circumstances, airlines, steamship lines or freight forwarders can be of valuable assistance. Private marketing consultants are in a position to provide exporters with information on regulations and market conditions, on a fee-paying basis; their knowledge and experience is extensive, and their interest is in the potential increase of their own business. Some have marketing facilities; all are able to assist in questions concerning import regulations, and costs and conditions of transport to the ultimate market area. A word of caution: market conditions, price structures and government regulations change rather rapidly, and all information must be accurate and up-to-date.

Direct contacts from producer to consumer or buyers are the key to establishing a foothold in a market area. The European market has traditionally been approached through exhibits at national or international trade fairs and exhibitions. Some are general, some more geared to specific industrial or commercial activities. European importers, wholesalers and distributors participate as both exhibitors or visitors. Valuable contacts can be achieved, and a good insight into competitive activities will also be of use. In addition, there are a number of other commercial manifestations available to an exporter, such as Trade Promotion Weeks or National Weeks in cities.

IV. Consumer Goods (Latin American market): Irvin Baskind, Inter-American Export Promotion Center, Bogota.

With total imports currently approximating $15 billion per annum, Latin America is one of the fastest growing regions in the developing world, providing ample opportunities for selling a wide range of

products. The region encompasses a multitude of markets differentiated by income levels, geographic conditions, climate, political factors, etc. At one extreme are Argentina and Venezuela, with per capita income approximately $1,000, while at the other are the Central American republics with an average slightly above $300, or Haiti with per capita income below $100. Within national boundaries, the differences may be even greater: in Brazil, for example, average per capita income for the country as a whole is estimated at $430. But in the highly advanced and rapidly growing southern areas comprising Sao Paulo and Rio de Janeiro the average is more than twice the national level, while in the northeast, despite recent progress, the average has only reached perhaps 40 percent. The essential point is fairly obvious—potential exporters need to exercise great care in the selection of the market they wish to penetrate. Moreover, the differences also demonstrate the wide range of products for which demand exists in the region.

In this selection process, potential exporters can avail themselves of the great mass of information now being collected for these countries which deals not only with current patterns of imports and general economic trends underlying trade flows, but also with commercial practices covering such matters as existing channels of distribution and marketing as well as principal importers, and with government regulations affecting imports. For exporters within Latin America who desire to increase trade with their neighboring countries, commercial information is available through the Inter-American Export Promotion Center (CIPE), established by the OAS in 1968 with headquarters in Bogota, Colombia. The Center has created an Inter-American Network of Commercial Information linking trade information services in the countries of the region with its central clearing house and library in Bogota. CIPE has made a number of market profiles on products and product lines of general interest to the countries of the region. For exporters in developing countries outside the region, information is available through the UNCTAD/GATT International Trade Center in Geneva which works in close cooperation with CIPE. Economic analyses and statistics are also available in publications of the Departments of Economic Affairs and of Statistics of the OAS in Washington; the United Nations Economic Commission for Latin America (ECLA) located in Santiago, Chile; and the United Nations Statistical Office in New York. Finally, many private commercial enterprises with international connections, particularly banks, transportation companies and insurance agencies, can provide assistance to exporters.

Note should also be taken of the growing use of international trade fairs and exhibitions within countries of the region, providing excellent opportunities for sellers to become familiar not only with local markets but also with buyers from neighboring countries. The public and private sectors in Sao Paulo are currently completing an extensive modern Inter-American Center for Fairs and Exhibitions which

will have a full-year calendar of activities. Bogota, Lima, and San Salvador have for a number of years boasted bi-annual trade fairs attracting increasing numbers of exhibitors from other countries within and outside the region.

Prospective exporters must keep in mind the existence in most countries of controls over imports and particularly over the allocation of foreign exchange for such purchases. While varying in their degree of restrictiveness, practically all governments have established import licensing systems and/or other measures to conserve scarce foreign currencies. These systems are generally designed to give priority to investment goods, construction materials and commodities which are industrial or agricultural inputs, and they tend to discourage imports of consumer goods; nevertheless, in certain countries such imports are permitted with less difficulty.

V. Furniture (U.S. market): Richard C. Sachs, President, Sachs New York, Inc.

In the large U.S. market, consumer tastes and preferences vary widely; significant demand exists for furniture in all price categories, with the largest volume of sales grouped around the middle prices. For example, living-room sofas with two matching chairs, and bedroom groups including a dresser with mirror, chest and bed, sell most readily in the $400 to $800 range. Currently, the most popular furniture styles include Mediterranean (Spanish influence), French Provincial, Italian Provincial, Modern, and Early American (or Colonial). Of these, Mediterranean has for several years been the most popular. If furniture manufacturers in other countries are interested in entering the United States market, they would be well advised to see American furniture styling, construction, and values at first hand, if possible.

Much of the furniture displayed by retailers is purchased from manufacturers or wholesalers at "the markets." The largest of these markets is the Southern Furniture Market, presently held for eight days twice a year, in late April and late October. During these markets, furniture manufacturers display their new lines in special exposition buildings or in their own showrooms maintained near or adjacent to their manufacturing facilities. In High Point, North Carolina, are located the Southern Furniture Exposition Building, with approximately 375 manufacturers' showrooms, and several other large furniture display centers. Within a hundred-mile radius of High Point, various important manufacturers maintain their own showrooms, and displays in several nearby cities are visited by buyers. Other regional markets of five to six days duration are held throughout the country twice a year, usually within two weeks before or after the national Southern Markets. In Chicago,

regional markets are held in the American Furniture Mart and in the Merchandise Mart. In New York, 375 exhibitors show in the Furniture Exchange and in the National Furniture Mart. Other semi-annual regional markets are held in Dallas, Atlanta, Los Angeles and San Francisco. These markets are the simplest, most direct way to present a line to retailers located throughout the country. For showroom space, the exposition buildings should be contacted directly.

VI. Fresh Fruit and Vegetables (from the Producers' Side—Central America): A. R. Van Hoven, Manager, Western Buying Office, Grand Union Stores—a grocery chain.

My experience in six countries has been that almost anything can be grown in Central America, but there are a number of reasons why produce may not be successfully exported. The first problem is that most of the people supplying the food in these countries are small farmers whose technical knowledge is extremely limited. In addition, refrigeration at market time is unknown, and as a result much of the local food supply is wasted due to decay and poor handling. I am convinced that, before a real export business for these countries can be developed, local marketing must be changed. One aspect of this is the local acceptance of uniform systems of grading for size and quality, so that sellers and buyers can communicate effectively. But suppose we do have a grading system and we know something about refrigeration: how do we get into the export business? Five important steps, I think, are necessary before the first seed is planted.

1. The most important step is to find a market in the target country, in this case the United States. To find markets takes a broker who not only can move and sell the merchandise, but can advise on things that should be grown. On my trips through Central America I found a distrust of brokers, apparently because of past experiences. However, most brokers are legitimate people: by obtaining a Produce Blue Book or Red Book, one can be certain how they are rated. Before the first seed goes into the ground, be sure a marketing arrangement is set up in the United States (or Europe, or Japan). Mexico has representatives at the border who have refrigerated sheds and sales organizations that cover North America.

2. The next step is to decide what should be grown. The broker can suggest marketable items but the important thing is whether they can be grown in the area, and this decision must be made by the grower. I have been asked many times in Central America about the markets for fruits and vegetables that are almost unknown in North America. My reply has always been that Central Americans must enter the market place with fruits and vegetables the North Americans know. Once established, the new and exotic fruits may be considered, and some can be merchandised and moved.

3. The next consideration is when to plant the items so that they will reach the market at the most advantageous time, i.e., the season when there is the least of the item. This is important to realize the highest profit; it would be a mistake to ship into a country at the time that country has domestic supplies. In order to make the market timing right, what will the weather be like at planting time? Is it the rainy season and can planting be done?

4. The next consideration is what type of container, or package is to be used to get the merchandise from farm to destination. This should be researched, as it is easier to sell merchandise that is sized and packed the way buyers are used to buying it. The broker can help, but a decision must be made in the field. Certainly, cardboard may be too high and wood may be cheaper; however, these items are being shipped long distances and weight becomes important. What happens to the refrigeration in each container and how can this be compensated for? How does the merchandise get harvested? Where is the actual packing to be done? How is the packing to be done? All these questions need to be answered long before the crop is in the ground. On one trip that I made I found a way of harvesting that certainly doomed the exportation of a product. The item was cucumbers, and the temperature in the field was 100 degrees F with humidity in the 70s. No picking boxes had been ordered, so the cucumbers were cut from the vine and piled in the hot sun in little piles in the field; from this point, they were carried to the end of the field and piled in a big heap. The cucumbers arrived in the U.S. a complete loss.

Oranges being packed after cleaning and grading, Libya. [Photo: Food and Agriculture Organization of the United Nations.]

5. The last point is refrigeration in conjunction with transportation. Different products require different maintenance temperatures: an example would be pink tomatoes which should have a transit temperature of 45 to 50 degrees F; while cantaloupes should have a transit temperature of 32 to 36 degrees F. Tomatoes at a temperature of 32° to 36° would show chilling injury, while the melons would show decay at the tomato temperature. All mechanical sys-

tems used during transportation are made to maintain temperatures and not to precool; any cooling of the product must be done before loading. We are dealing with living items that are highly perishable; no half measures will make a success of the fresh fruit and vegetable export business.

VII. Fresh Fruit and Vegetables (from the market side—U.S. market): E. R. Mead, U.S. Department of Agriculture, Hunts Point Market, New York.

Improvements in the transportation and storage industry are changing and broadening eating habits and the markets for many commodities. A few years ago, for example, the marketing of avocados and mangoes was mainly confined to points near their producing areas, while fresh strawberries and many other commodities were only available for seasonal marketing. Today these commodities are available in many markets of the world all year around. Many markets are more quality conscious than others; the sizing, variety and packaging acceptable in one market may be totally unacceptable in another. These and many other conditions have complicated and increased the problems of marketing. Despite the overall expansion, new producing countries have often found they cannot compete because they failed to know or accept and meet the standards or the very particular requirements of competitive marketing.

Experience indicates the importance to producers and shippers of having a representative in the destination markets. A basic factor, other than his honesty and credit rating, is this representative's ability to sell the exporters specific commodities. A good salesman in the fresh fruit and vegetable industry is a specialist; time after time he will get more dollars for a package than another salesman with less ability or knowledge. The number of restrictions on commodities is increasing in many markets; these include various types of marketing agreements or state marketing orders, and rules concerning pesticide and insecticides, sizing and condition, type of package, fumigation, tonnage allotments, etc. Regulations to prevent the spread of diseases or insects are often misunderstood, or incorrectly communicated. (Recently, for example, a shipment of grapes from Colombia was rendered almost unsaleable in New York by being given a second and unnecessary cold treatment. The transporting carrier did have and had used the equipment to give the cold treatment required for immediate release in the U.S., but lack of communication and understanding between the receiver, shipper and our government forced the grapes to undergo the cold treatment again. The loss to shipper and receiver was almost $20,000.) A shipper's representative must have an intimate and current knowledge of these regulations, and also be able to advise on the competition that can be expected from both domestic sources and imports. Producers and

shippers should maintain honest and current communications with the representatives and keep them posted accurately as to the condition, quality and probable volume that can be expected for the coming shipping period.

As a general rule most importing markets are quality markets, so unless a market is completely bare it is often wise to keep poor quality and off-size stock at home or arrange for other outlets; it is almost impossible to sell such fruit or vegetables at any price when in competition with good quality. In the large terminal markets every major commodity is generally in competition with the same commodity from other producing areas or countries. This competition dictates that the quality, sizing and the maturity of the commodity be uniform from the top of the package to the bottom. There are fewer buyers today on these large markets; instead of buying for a comparatively few independent retailers as in the past, they are now buying for hundreds of retail stores, each store demanding the same uniform quality and size commodity. This often makes it possible for the seller to get an appreciably higher price for a large lot of uniformly high quality fruit or vegetables. New shippers need to pay special attention to timing, and to the volume a market has absorbed of their commodity at profitable prices in the past. They must take into consideration how much their added volume may affect the market: perishable prices are generally closely related to the volume of supplies, and a 10 percent oversupply or undersupply on a particular day or week may mean a 50-100 percent change in the selling price. If a commodity is expected to be in oversupply, however, a quick consumer promotion through the press, radio and television can often increase the demand enough to maintain profitable marketing returns.

Tariff and Non-Tariff Barriers to Trade With the Developed Countries

Keith E. Jay

[Tariff barriers to imports into developed country markets are being slowly reduced, so the non-tariff barriers on exports of products from developing countries are attaining more importance.]

The discussion of trade barriers has usually centered on the levels of tariffs, on the assumption that tariffs represented the major deterrent to trade. During the 1950s and 1960s, the trade negotiations culminating in the Kennedy Round significantly lowered the overall tariff barriers in the developed countries. For example, tariffs on dutiable non-agricultural products will average only 9.9 percent in the United States, 8.6 percent in the EEC (European Economic Community), 10.8 percent in the United Kingdom and 10.7 percent in Japan when the final Kennedy Round reductions are made. In the 1970s, developed country tariff barriers are becoming still less important to developing countries as a result of the Generalized System of Preferences (GSP). Under the GSP most developed countries are granting duty-free entry on a broad range of manufactured goods from developing countries and in certain cases the GSP has included agricultural as well as manufactured goods. As of March, 1972 Australia, Japan and virtually all of Western Europe had put GSP schemes into effect, while the U.S. and Canada are still considering GSP actions.

With the reduction of tariff barriers, the visibility and the relative impact of non-tariff barriers on developing countries have increased. Non-tariff barriers

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have traditionally been used and are currently being applied to those products which are of particular export interest to the less developed countries. Table 1 indicates that the major product categories covered by non-tariff barriers are: processed meats, processed fruits, beverages, textiles and petroleum. Food processing and textile production are by nature labor intensive, and developing countries tend to have a comparative advantage in their production. Petroleum exports originate largely in developing countries where oil fields have been discovered. The less developed countries have for these reasons become increasingly concerned with the growing spread and restrictiveness of the barriers they face, and this concern has led to a great deal of discussion and investigation in international forums concerning barriers to their trade. The movement toward the use of non-tariff barriers has in fact accelerated in recent years, as protectionist forces within the developed countries have attempted to insulate their domestic market from competition in the agricultural or labor-intensive manufacturing sectors. Notable examples of this type of protection are the Common Agricultural Policy of the EEC, the Long Term Textile Agreement; and the U.S. oil import quota.

Non-tariff barriers are applied to some extent by all developed countries. As Table 2 shows, the use of non-tariff barriers varies widely among developed countries, reflecting in part the ability of the countries to compete. France clearly uses non-tariff restriction more than most developed countries, far exceeding the incidence in countries such as Canada or Australia. (Note: these figures on numbers of restrictions do not, of course, indicate how restrictive any one of them is in its effect on potential trade.)

The major types of non-tariff barriers are: 1) import quotas, 2) discretionary licensing, 3) variable levies, 4) internal or border taxes, 5) health and labeling regulations, 6) government purchasing requirements. The best known and most visible are the quantitative restrictions, or import quotas. Though often referred to as an alternative to tariffs, the general impact of quotas is more restrictive and distorting than tariffs. A quota short-circuits the price system, and such interference with the allocative function of prices can very easily create monopoly profits for domestic sources. In addition, quotas can be used more explicitly than tariffs to prevent or limit the growth of imports over time. It is this last feature which is so appealing to protectionists, since it assures that the level of foreign competition can be held constant in the future regardless of any growing inefficiency of domestic producers. Three of the best known quotas are those placed on meat products, sugar and petroleum. Most developed countries not only restrict imports of sugar but also subsidize domestic production, so the restrictive trade impact on this one product alone is quite large. It has been

Table 1: Frequency of Non-Tariff Import Restrictions Applied, According to Product Group

Product Group	1968 Imports by Developed Market Economy Countries That Maintained Restrictions in 1971 (Millions of dollars)	Frequency of Restrictions[b] (Percent)
BTN chapters 1-24		
Processed meat products	114.6	21.4
Processed cereal products and preparations	16.4	24.6
Processed fruit products	118.7	22.5
Processed vegetable products and edible preparations	61.5	12.5
Sugar, sugar derivatives and chocolates	4.4	7.9
Beverages and alcohols	96.0	7.9
Tobacco manufactures	2.1	1.8
Other products	0.3	1.4
Total	414.1	100.0
BTN chapters 25-99		
Woolen products	1.5	4.0
Jute products	25.9	4.9
Other textile products	62.3	17.7
Petroleum products	1,199.9	16.1
Ceramic products	0.1	4.2
Leather and leather goods	7.4	1.5
Electrical and mechanical appliances	4.0	9.4
Other products[a]	25.0	42.2
Total	1,326.0	100.0

a/ Including products of chemical and allied industries; basketwork; paper articles; base metals and articles thereof; optical, photographic and measuring instruments and toys, etc.

b/ Each particular type of restriction is counted once for each country applying it to a particular product or group of products.

SOURCE: UNCTAD, "Program for the liberalization of quantitative restrictions and other non-tariff barriers in developed countries on products of export interest to developing countries." TD/120/Supp. 1, January 31, 1972.

Table 2: Frequency of Import Restrictions Applied in Individual Developed Market Economy Countries on Products of Export Interest to Developing Countries

Importing Country	Number of Products Affected by the Restrictions	Frequency of Restrictions Applied[b/]
France	88	140
Federal Republic of Germany	40	54
Italy	33	38
Benelux	25	27
Denmark	26	29
Finland	26	33
Austria	22	37
Norway	20	26
United Kingdom	17	19
Sweden	17	17
Switzerland	13	24
Japan	34	34
Ireland	21	21
United States	15	17
Canada	11	11
Australia	4	4
		531
Total Products Affected	130[a/]	

a/ About 50 percent of these products are affected by restrictions applied in more than one country.

b/ See footnote (b) in Table 1; more than one type of restriction may be applied to a product in a given country.

SOURCE: UNCTAD (see Table 1).

estimated that removal of the U.S. sugar quota and subsidy, for example, would increase developing countries' foreign exchange earnings by close to $250 million a year.

One variant of quota restriction is the "voluntary export quota." This technique was revived in the mid-50s when the cotton textile export capacity of many less developed countries was expanding rapidly, and the resulting pressure on developed country cotton industries led to a call for relief. The importing countries were able to "convince" the exporting countries that it was in their best interest to restrict their cotton textile exports by their own legislation as an alternative to even more restrictive quota legislation in the importing countries. The outcome of this activity was the Long Term

Textile Agreement which has been in effect since 1962. The voluntary quota technique has subsequently been expanded to steel and to other textiles.

Accompanying most quota systems is the use of discretionary import licensing, since any quota which is constraining requires some system to determine who will be allowed to import what quantities and from where. The manner in which the government administers these licenses can, in itself, create an additional barrier to imports. Delays may occur in the issuance of the license, cash deposits or other financial constraints may be imposed as prerequisites to their issuance, or the licenses may be issued to certain companies, or for imports from certain countries, which will assure that the quota will not be fully used.

A third type of restriction which is similar to the quota in its nature and impact is the variable levy. This technique, which is an integral part of the EEC's Common Agricultural Policy (CAP), also effectively removes price from the import equation. The EEC first determines the desired market prices for its domestic farm products. Imports of those products are then assessed with tariffs equivalent to the differences between the world market price for the product and the CAP pegged price. Regardless of the prices of the agricultural products on the world market, they enter the EEC only at the established price. The domestic producers are thus assured of both their selling price and a market.

The remaining non-tariff barriers—border taxes, health and labeling requirements, and government purchases—are problems faced by all trading nations and are far less specific to developing countries than quotas and variable levies. The border tax, like the variable levy, is a major factor in the economic policy of the EEC. The basis of the border adjustment is the value added tax which is now generally employed throughout Europe. Since the value added tax is an indirect tax, it can, under GATT law, be rebated or assigned at the border. Goods flowing between two countries which apply a value added tax are not greatly affected since the tax on the good in the exporting country is rebated while the importing country's tax is assigned on importation. According to GATT rules direct taxes such as income or corporate taxes cannot be rebated or assigned at the border. Goods entering a country using a value added tax system from a country which emphasizes direct taxation bear not only the cost of the exporting country's direct taxes but also the value added tax of the importing country which is assigned at the border. The impact of the border tax system is to increase the cost of imports from countries with direct taxes by, in effect, double-taxing those imports. Because of the general use of value added taxes within the EEC, there is added stimulus to intra-EEC trade at the expense of many of the countries outside the EEC.

Health and labeling requirements exist in all countries, but the severity of the requirements adopted generally increases with the level of development of the country, and the requirements of the developed countries are the highest such barriers to trade. Health requirements exist basically for a socially desirable reason; however, they can also be used as a means of protection, and the relative influence of these two motives is usually impossible to determine. It is unlikely that these requirements will be reduced; on the contrary, they probably will be strengthened over time. Unfortunately the developing countries bear a major portion of the burden imposed by health regulations, since the majority of all health restrictions apply to raw and processed agricultural products and because the developing countries face a much more difficult problem in meeting the health standards. Typical health requirements faced by exporters are those applied to beef and citrus fruits.

In the area of labeling, the developing countries are also in a more difficult situation than the developed countries. Many of the latter have very specific requirements for identifying products by name, by chemical content, by measurement, or by other designations required by each country's laws, and these often vary widely from one country to another. As a result, exporters in developing countries may have to make up separate labels for identical goods going to different countries, and keep up with changes in such requirements—a burden on small firms and especially those who are new to foreign trade.

A final non-tariff barrier is government purchasing requirements. Most countries do not have formal legislation requiring the purchase of domestically produced goods by the government. The major exception is the U.S., which has its "Buy American" rules that give advantages to domestic suppliers; through the 1960s, for example, the Defense Department has been required to give a 25-50 percent price preference to domestic producers. The absence of specific laws in other countries does not mean that similar policies do not exist, however. By controlling the timing, the amount of information given and the specifications for contracts, most governments are able to direct most of their purchases to domestic rather than foreign sources.

With this extensive list of barriers faced by the less developed countries, one may wonder what can be done to improve the situation for their exports. What can individual countries do to aid their exporters in overcoming some of the non-tariff barriers which they now face? What can the developing countries as a group do to remove the biases which exist in the developed countries against the products of greatest export interest to them?

To assist domestic firms within the developing countries in overcoming those barriers whose major restraining power derives from requirements for more information, their governments should establish a qualified bureau which can provide information on developed country requirements and can assist their companies in meeting those requirements. This is particularly relevant for health and labeling restrictions. In addition, where the health conditions of the country rather than the firm are the major restraint, the country should adopt whatever measures are feasible to correct the problem.

For the other barriers to trade, action by the less developed countries as a group is necessary. The developing countries should continue to discuss in international forums, such as UNCTAD, GATT and the UN, the nature and magnitude of current trade barriers and the possible actions which could be taken by all countries to reduce these barriers. The problem has become more complex as the overall levels of tariffs have been reduced leaving non-tariff barriers as the major constraint. However, international action to reduce non-tariff barriers has not been attempted to any great extent in recent international trade negotiations. New ground rules and new frames of reference need to be worked out to deal with this type of negotiation. In this connection, there has been considerable discussion recently on the possibility of a multilateral trade negotiation to begin in 1973. In previous multilateral negotiations the developing countries were generally excluded from active participation; but today, when many of the remaining barriers relate specifically to their interests, it would be only logical for the developing countries to play a more active role in any future negotiations.

[An original article.]

Export Processing Zones

Angus Hone

[An EPZ can make a small but significant contribution to a country's exports. For it to have an impact like that of the successful examples in East Asia, however, certain rather demanding requirements have to be met.]

Export processing zones (EPZ) have worked remarkably well in a number of small countries which have followed flexible economic policies designed to give maximum assistance to their exports and their exporters. Often, the conditions inside the processing zone and outside of it have not been very different: import of raw materials for subsequent export is freely allowed, capital goods do not require licensing, repatriation of profits and capital is comparatively uncomplicated. The main difference is that bureaucratic procedures within the zone are kept to a minimum, and decisions from government on zone investment are usually quicker. What, then, are the possible advantages and disadvantages of such zones? What are the underlying theoretical and administrative causes of their success or failure?

The great success of the export processing zone in Kaohsiung in southern Taiwan is well known. The first products from Kaohsiung were exported in early 1967—two years after the statue for establishment of EPZs was passed. By the end of 1970, Kaohsiung had 162 factories, representing a total investment of $40.9 million; its exports in 1970 were $109 million; and 40,800 workers were employed at the end of the year. All the land at Kaohsiung had been exhausted and two

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new EPZs were being established at Nantze and Taichung. Similar developments have been going on in Korea since 1967 in bonded warehouse areas around Seoul and at the new free port of Masan. The government of Singapore has been actively promoting similar industrial investment on the Jurong estate. In the Philippines, the Marieles free trade zone has been established, although very little investment has actually taken place. There are recurrent rumors that Malaysia, Thailand, Indonesia, and Ceylon all plan to establish export processing zones or free trade zones as part of their efforts to attract foreign investment in export industries.

Indian discussion of processing zones starts from—and also suffers from—the fact that India's only example of EPZ, Kandla in Gujarat state, has been a disastrous failure. Though investment there has picked up since 1969, Kandla has not had any impact on exports, it has not attracted "high technology" industries to India, and it has not provided significant employment. Why did it fail? First, it was in the wrong place: far from Bombay, far from any international airport, and it suffered from very bad communications and poor living conditions. Second, there was no international campaign to promote the concept. Third, the Indian exchange rate at the time of Kandla's establishment (Rs 4.76 = U.S. $1) meant that India was extremely uncompetitive in all the likely manufactures from such a zone such as electrical and electronic goods, garments, wigs, plastics, rubber products, and toys. Finally, procedures for investment, capital goods import, raw material imports, capital remittance and sale of second-quality goods in India, were still hopelessly complicated. It is hardly surprising that the concept failed given these disadvantages. Recently, the processing zone concept has been revived in the Airport Electronics Scheme sponsored by the Trade Development Authority, which would allow foreign investors and their Indian collaborators to import raw materials and to export finished electronic components freely from a bonded site near Santa Cruz; and there is the possible development of a more substantial zone in the Twin City plans for Bombay.

It is important, however, to recognize that export processing zones do not, and cannot, act as a major stimulus to the export economy. Kaohsiung in 1970 contributed less than 5 percent in gross terms to Taiwan's exports. Masan and other zones contributed even less. It is advisable to calculate the net contribution as only 2/3 of EPZ exports; imported raw materials and components often run as high as 50 percent of gross exports. Also, EPZs in Taiwan, Korea, and Singapore, could not have been a significant attraction had not the basic atmosphere there been strongly biased in favor of free trade and free entry of foreign private capital—even though location of zone, air freight, packaging and shipping facilities, all contribute their share to success. The bulk of investment is American and Japanese,

and the U.S. and Japanese markets are the target markets. (All the zones were badly hit in late 1971 by the U.S. dock strikes.) Finally, even the marginal gains to the export economy from any new zones are bound to be smaller because the earlier zones have pre-empted the larger investments from the big international companies who will have by now planned their long-term sourcing of components; these companies will not want to scatter management time on a number of small units spread around the Bay of Bengal.

Nevertheless, the contribution of processing zones in India could be worthwhile. A zone would allow certain industries—which are crippled by high material costs and inappropriate local machinery—to develop. The obvious industries are the garments, electrical fittings, electronics, plastics, toys, precision instruments, and preserved fruits and vegetable industries. All these industries are plagued by high cost of polymers, synthetic fibers, packing materials, etc. Yet, Indian labor costs and—far more important—Indian inspection, supervisory and management costs, are highly competitive. Moreover, such a zone would give foreign investors a chance to use the most modern and productive machinery freely. This would act as a "demonstration of new processes" to Indian producers outside the zone. And the zone might attract international companies otherwise kept at a distance by the usual bureaucratic tangles. A series of such zones could make a net contribution of $50 million by 1980. Admittedly, this would be only 2 percent of the exports anticipated by then, but it might still be worthwhile for the "high technology" products which, without such zones, would not be produced in India and are excellent for India's product image in world markets. The processing zones can also provide employment to labor, particularly semi-skilled labor, which is usually abundant near major airport and seaport cities where the zones would be most satisfactorily located. The zone wage rates might be set by the government, but should certainly not exceed the local (non-zone) average for similar grades of labor.

The dangers of smuggling as a result of EPZ can be administratively minimized. The area could be policed and enclosed, but a far more potent weapon lies in the free zone's concentration on producing goods that are largely unsaleable in the domestic market, being usually produced as components for foreign products and to foreign designs and specifications. The items most commonly smuggled in India—synthetic yarns, special steels, automotive parts, consumer durables, gold, pharmaceuticals and garments—are rarely produced in free trade zones. Garments are the obvious exception but, usually, stringent rules for legitimate sale of "rejects" can conveniently take care of this—such as that "rejects" should not exceed 5 percent of production.

India has some endowments for leading in exports from export processing zones in the 1970s, which are closely allied to excellent air communications and reasonable sea freight opportunities. The labor and management skill base here is substantial too; in addition, the local engineering supply base in terms of dies, jigs, tools, fixtures, and design and drawing office ability, is the most sophisticated in Asia outside Japan and is certainly the lowest in cost. The other essential ingredients of a successful zone could be established, once Government of India is convinced that such zones are worthwhile—without radically altering the domestic economic policy options.

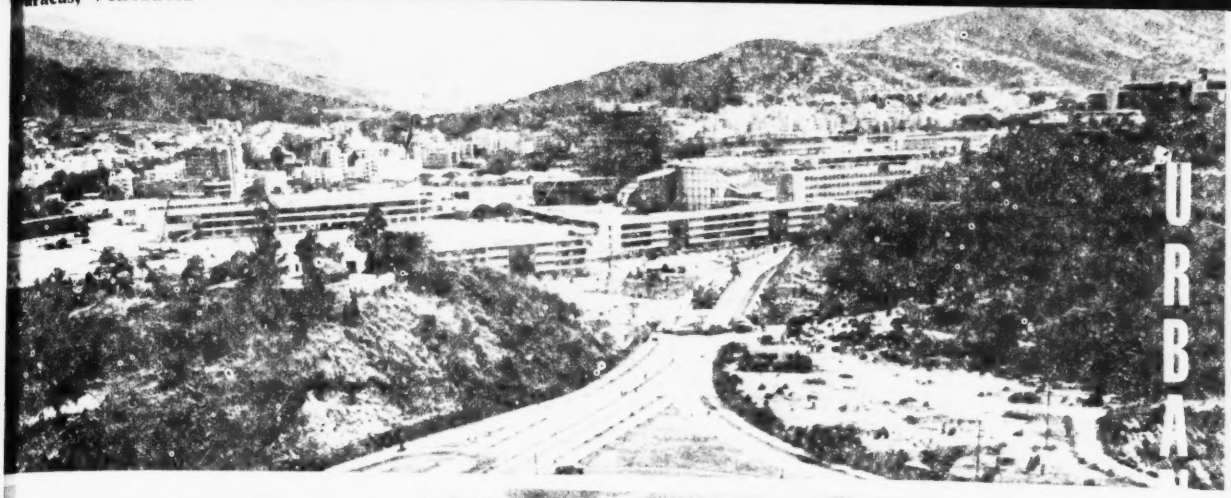
There is, however, a host of facilities required if a zone is to compete successfully with other zones in Asia. The zone would probably have to offer a liberal tax holiday (3 to 7 years). Repatriation of capital profits and interest would have to be free (for foreign companies) although domestic taxes and rules on capital retention may be applied to local company investments in the zone. There should be ready supplies of low cost labor subject to whatever productivity adjustment is required to bring local wages into line with those in Taiwan, Korea, Singapore, etc. Water and power supplies have to be regularly available at internationally competitive prices. It has to be made extremely easy and quick for a new investor to be able to acquire industrial land with access to drainage, roads, power and water. The country would have to attempt to provide standardized factory buildings designed for the industries the zone is supposed to attract. Impost/export procedures would have to be adjusted to approximate to those of Hong Kong and Singapore. The system of transport within the zone must be simple and there should be adequate warehousing for finished products awaiting shipment. Finally, the international air and sea transport links should be regular, relatively cheap, and able to move the goods produced quickly to their markets. (These conditions were not all satisfied in the old free ports of Hong Kong, Singapore, Penang and Aden.) Above all, the stress during the operation should be on accommodating the problem of the exporter rather than on strictly applying the letter of the law.

[Excerpted from "Export Processing Zones: Gains at the Margin," Economic and Political Weekly. Bombay: A Sameeksha Trust Publication, Vol. VI, No. 47, November 20, 1971, pp. 2345-2347.]

Ibadan

Amma

Caracas, Venezuela



Ibadan, Nigeria

Amman, Jordan

URBAN VIEWS OF CARACAS, IBADAN AND AMMAN.
[PHOTOS: CREOLE PETROLEUM CORP. AND FAO.]

Urban Concentration in Developing Countries

E. A. J. Johnson

[Less developed countries have too few market towns throughout their countryside to bring about commercialization and progress in agriculture; their urban growth tends to be over-concentrated in a few large cities. Causes, and methods of remedying this condition, are explored.]

The Organization of Space

Differences between progressive and backward countries or areas within countries can usefully be assessed in terms of the ways whereby terrestrial space is organized. Thus, if military control of an area is a chief object of policy, the landscape will be studded with forts, castles, cantonments, and other military or paramilitary institutions strategically located; and the building, maintenance, staffing, and provisioning of these installations may require such a large share of resources and manpower as to arrest or limit seriously the development of non-military institutions and activities—for example, the castles and manorial estates of medieval Europe. Somewhat different effects on a landscape may result when a priestly group controls the people who occupy a given compass of land. Thus, in Christianized Europe a network of dioceses and parishes was established, each with its complement of clergy. The temples of ancient Egypt, the Buddhist and Hindu shrines of South and Southeast Asia, the Shinto fanes of Japan, and the mosques of Islamic regions called for some corresponding organ-

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ization of people, and of landscapes. Another type of spatial organization centers around juridical institutions, a network of courts, assizes, and other adjudicative agencies created and located to insure an operative set of procedures. A fourth variety might be administrative control over both land and people in a dependent area. Thus, a conquered territory will pay tribute to collectors of revenue; the landscape will be under the influence of "collectors" or tax farmers, and its structure, its capacity for improvement by means of investment will be singularly conditioned by the character of the administrative procedures and by the incidence of the taxes and contributions.

A fifth, and by all odds the most important, means for organizing a landscape is a hierarchy of markets that interlinks the economic activities of the people of an area into some meaningful arrangement. By making exchange of goods and services possible this scheme of things not only permits specialization of tasks and division of labor but creates beneficial interconnections between regions and persons that hold society together. It should be noted, however, that a military organization of a landscape will require some of this economic mechanism for its operation, as will a sacerdotal, a judicial or an administrative system; and a market organization requires administrative and other units. What really determines the nature of a landscape, therefore, is the extent to which military, sacerdotal, juridical, administrative, or economic influences predominate. The argument here is that in less developed countries landscapes have been inadequately influenced by market forces.

The role of a hierarchy of markets in the organization of economic landscapes. In complex, highly differentiated economies we are so accustomed to this form of spatial organization that we take it for granted, but there are vast areas of the world community which are hardly commercialized at all, and even greater areas which are very imperfectly provided with exchange facilities. A random scattering of small market points where exchange of goods or services occurs occasionally is a far cry from a systematic organization of a landscape by means of an interpenetrating market system. A truly effective exchange arrangement, which will permit producers to specialize, depends upon local collection points and larger regional assembly centers that are interlinked by a sales and payments system which provides incentives for producers and at the same time facilitates the distribution of goods in accordance with consumer preferences. A mechanism of this type, capable of integrating production, distribution, and payment, is normally a product of historical forces, not something that can be fashioned or created quickly. But, although it cannot be devised at will, its emergence can be hastened by planning and wise policies.

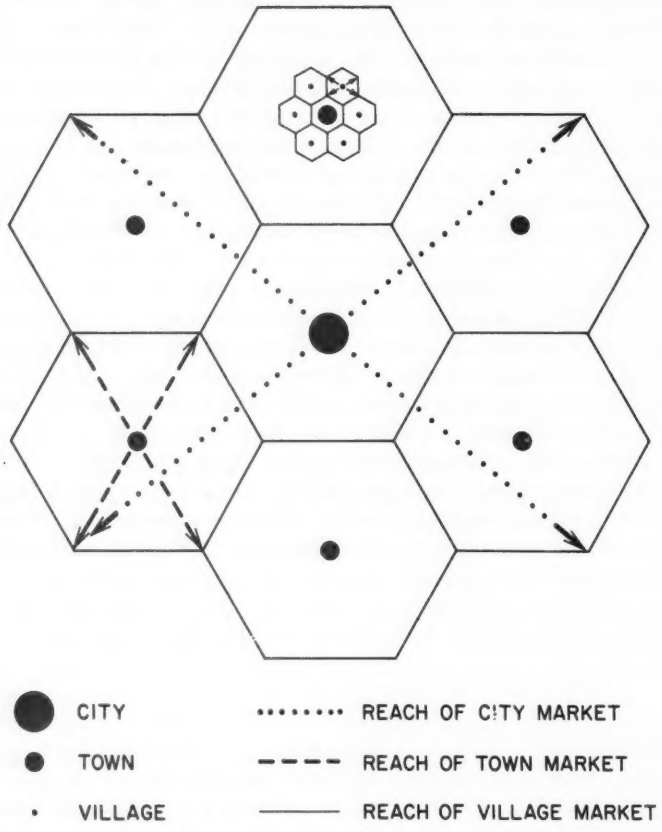
When a landscape is organized by such market forces a hierarchy of exchange centers—"central places"—will normally evolve. Small

local assembly and distribution activities will be found in villages and hamlets, and these markets will cater to the needs of people living in a relatively small encircling area. The perimeters of such local market areas will depend on the nature of the topography and on the road, rail, and water transport facilities. But these small markets, which for convenience may be called village markets, are interrelated with larger markets located in towns and cities. Surplus products from the village markets move to the town markets, while goods too specialized for villages to produce move from the towns to the villages. As an economy becomes more urbanized, still larger markets will develop in certain cities, particularly in urban centers strategically located for trade (at ports, river junctions, and railway centers) or for specialized production (near deposits of natural resources, near water power, or favored by other important locational factors). To these city markets both town markets and village markets will be delicately attuned, so that the entire hierarchy of exchange facilities will operate as an economic organism influencing the growth and development of an entire region. Moreover, some parts of the market system, usually the city components, will be interrelated to varying degrees with foreign markets. Through these complex interconnections consumers in far distant cities will transmit their demands for meat, wool, cotton, or grain to remote village markets, while producers in foreign countries will supply the tea, coffee, or style goods for shops in domestic city, town, or village markets.

If such a system were developed in an agricultural region where there were no topographical variations that would interfere with the most direct travel, and where no constraints prevent the construction of adequate roads, the pattern of market organization that would in theory result could be visualized as shown in Figure 1. In the center of the plain would be a city representing the largest single component of the regional market system. By the dictates of geometry the city would be surrounded by a band of six towns, each controlling a trade area roughly one seventh of the total regional area dominated by the central city. The trade area of each town market in turn would be divided into village trade areas (one of which is shown inside the top hexagon in Figure 1.) The basis for a six-sided, or hexagonal, form is the requirement that market places should be the shortest distance from the largest number of evenly spaced farms. The size of the hexagons depends on distance to be conveniently covered using the prevailing means of transportation. In this ideal market allocation the entire region would be fully commercialized since all persons would be within convenient reach of some part of the market system.

In the long history of economic development a great deal of experimentation has been made in spatial organization. The complex meta-

Figure 1: A Hierarchy of Market Centers and Market Areas



morphosis of the European manor, for example, was really a chapter in the search for tolerably satisfactory patterns of agrarian resource allocation. In recent times the Russian attempt to operate townless agrarian landscapes is yet another chapter in this ceaseless search. But except for the Soviet ventures, which are based on the assumption that traditional municipal economic functions can be performed by collective farms and machine tractor stations, a successful configuration has consistently had a market town as its economic center. Consequently the key to the economic development of countries or regions is normally to be found in the historical relations between town and country. The more contexts in which this phenomenon is studied, the clearer it becomes that development is a function of agrarian commercialization, and that the rationalization of agrarian conduct under a pecuniary stimulus calls for a network of conveniently located central places where efficient exchange of goods and services can occur.

Central-Place Inadequacy in Underdeveloped Countries

There is an astonishing difference between developed and underdeveloped countries in their relative number of central places and in the dispersion of these towns, small cities, and larger cities. In the developed countries the varied hierarchy of central places has not only made possible an almost complete commercialization of agriculture but has facilitated a wide spatial diffusion of light manufacturing, processing, and service activities, and these establishments provide employment of a differentiated variety. The relative lack of such a central-place infrastructure in underdeveloped countries leads to serious handicaps. Because the countryside is inadequately provided with accessible market centers where farm produce can readily be sold and where shops with consumer and producer goods can exert their tempting "demonstration effects," the incentives to produce more for the market and the inducement to invest in better tools, fertilizers, or better livestock in order to generate a larger marketable surplus are weak. A second handicap stemming from the inadequate number and faulty distribution of central places is rural underemployment and a dissipation of ability and talent. Young people have no way of knowing what talents they may actually possess unless they have some opportunities for experimenting; if their lives are confined to a rural economy where the only thing visible on the horizon is a landscape of villages, their latent proficiences, unperceived aptness, and unsuspected creativity may never be released. There are many other unfortunate consequences. Since only marginal produce is sold by operators of near-subsistence farms, there need be no systematic adaptation of products to consumer wants. There is little or no quality control; hence the value of salable produce is low. Without access to truly competitive markets, farmers can be victimized by monopsonistic village traders while their urgent need for cash income usually compels them to sell their produce immediately after harvest when prices are lowest. All these factors limit the income and thereby the saving and investment that farmers in underdeveloped countries can make, thus perpetuating a low-productivity type of technology. Until more and better market centers are developed there is no escape from this web of chronic adversity.

The only universal yardstick that seems useful for measuring the degrees of central-place abundance or deficiency is the ratio between villages on the one hand, to towns and cities on the other. Applying this test, it becomes apparent that developed countries have a very low ratio. Thus, no European country has a higher village-town ratio than 1 town to every 72 villages (Austria), and in some countries the ratio is as low as 1 to 5 (Switzerland). The median figure is 16. The contrast in the village-town ratio between Europe and the Mid-

dle East may readily be seen: except for Israel with its very low ratio (which compares with that of Switzerland) and Lebanon (approximately on a par with Ireland), all the other countries save Kuwait (which is sui generis) have ratios over 100. The median is 157. Roughly then, using only the median as a measure, Europe has ten times as many central places per village as the Middle East.

A rough correlation between the village-town ratio and per capita gross national product is shown in Table 1. One can see that, generally speaking, the countries with relatively more towns have higher per capita GNP figures and that GNP falls as the proportion of market towns decreases. Thus in the Middle East, Yemen with one town (over 2,500) for every 146 villages has a GNP of $62, whereas Lebanon with a town for every 23 villages has a GNP of $427. In Asia there are equally striking contrasts: Indonesia with but one town for every 355 villages has a GNP of $95, while in Malaysia with a town for every 87 villages, the figure is $308. To be sure these are very crude indexes, but the consistency with which they indicate the depressing influence that lack of towns and small cities can have on personal incomes cannot be ignored. The raising of average incomes in underdeveloped countries will require town-building programs; this is needed not so much to increase the overall level of ubranization as to improve its functional qualities. The difficulty is not the lack of scattered weekly or seasonal produce and peddlers' markets, for these may exist in large numbers. The real deficiency is in towns large enough to maintain daily, competitive produce markets, supplied with shops where farmers can buy the consumer goods they need and with stores where inputs such as fertilizers, pesticides, and other farm supplies can be purchased.

Great Cities and Dual Economies

In less developed village-structured economies, cities are not only relatively few but inordinately large. Consequently, a satisfactory interconnection between town and country by means of a hierarchy of central places, functionally dispersed over a landscape in descending scale of utility and size, is either lacking or so imperfectly developed as to leave large unserved interstices. There are two major reasons for the disproportionate size of the relatively few cities. In the first place a primate city is customarily a capital city, an administrative center where the ruling classes reside together with their entourage, their retainers and servants, and where artisans, politicians, and professional people who cater to the needs, desires, and whims of the patricians will perforce also congregate. Since the lesser aristocracy, with homes elsewhere, will need to curry favor with the dominant aristocracy, they may find it expedient to establish part-time homes in a central administrative center. In large countries several such administrative centers may grow up,

Table 1: Village-Town Ratios Compared with Per Capita Gross National Product (GNP)

Country	Ratio	GNP
Israel	6	$ 1,504
Sweden	23	2,735
Lebanon	23	427
Italy	24	1,182
Uruguay	36	611
Greece	41	764
Chile	77	588
Argentina	86	826
Malaysia	87	308
Iraq	98	254
Syria	99	187
Egypt	108	179
Turkey	117	322
Yemen	146	62
India	185	92
Algeria	218	228
Sudan	262	101
Iran	269	239
Indonesia	355	95

SOURCE: United Nations, *Demographic Yearbook, 1966,* New York, 1967; *World Almanac,* New York: Doubleday, 1968.

and the linkage of provincial capitals with a central capital will usually be more political than commercial. All this seems to apply whether the ruling group is a landowning aristocracy, a traditionalist or a modernizing bureaucracy.

A second reason for the disproportionate size of large urban centers vis-a-vis smaller cities or towns in less developed countries is to be found in the polarizing influence of linear forms of transport facilities that connect a primate city, or any other large city, with portions of village-structured rural landscapes. This second agglomerating force, which is more economic than political, tends to exaggerate investment at the poles of a transport axis, concentrate enterprises of many varieties at such terminal sites; and this growing concentration lures talented and adventurous people to the larger cities by leading them to believe that differentially higher incomes are to be found there—a hope that may or may not materialize. All too frequently the migrants find themselves unemployed, underemployed, or precariously employed with incomes so low or so uncertain that they must live in the jungle of slums, which are, unfortunately, so characteristic of great cities in underdeveloped countries. These two agglomerating forces, one mainly political, the other chiefly economic, largely explain the dichotomous character of settlement in Africa, Asia, the Middle East, and Latin America.

There is probably no general explanation that can adequately account for the high degree of political polarization so often found in less developed areas. Cultural and historical factors, including methods of colonial administration, undoubtedly supply precedents and explain particular elements in these centripetal forces. But for the most part it may be said that underdeveloped countries are not merely economically backward; the chances are that local and provincial government is not well articulated, and this means that authority tends to be centralized rather than delegated and diffused. Moreover, very often a government depends on a military rather than a popular sanction, and most such governments will tend to follow the military precedent of pyramidal centralization. For the purposes of this enquiry, the influence of political centrality on the emergence of great cities is simply taken as part of the given data. Djakarta, Rangoon, Belgrade, Accra, Lagos, Baghdad, and Cairo are large cities not merely because they happen to be trade and manufacturing centers but also because they are the foci of political forces; we must accept this political centrality as a fact that influences the way an underdeveloped economy functions. But policy should concern itself with the question of whether the persistent process of superurbanization should be encouraged or restrained. The problem is one of proportion. How large should the great cities be in relation to other central places in order to insure a tolerable macroeconomic functioning of the total economy of which they are such strategic parts?

The economic aspect of this puzzle is perhaps more amenable to appraisal inasmuch as certain polarizing factors can be isolated and analyzed. First a few words about the influence of linear forms of transport on the costs of goods movements and the resultant polarizing effects. More than anything else it has been railways that have enlarged, or even created, large cities. This is because each railway line constitutes a traffic axis along which traffic (and therefore trade) can flow more cheaply in a linear path than it can be diffused over an economic landscape. Some "spread effect," can be achieved by branch lines, but since such lines will have lighter traffic than the main lines, the unit costs of transport on the branch lines will be higher, and these relatively higher transport costs will operate to the disadvantage of the producers and consumers outside the belts of influence of main lines. Moreover, railway builders instinctively conceive of branch lines not as independent transport routes but as the means of feeding more traffic into main lines, thus creating a unified transport system which accents polarized development at the great city terminals.

Although modern highways can and do provide an increasing volume of linear traffic and consequently have certain polarizing effects, a road system is not a line having only one dimension, but a network

having in effect two dimensions along either of which (or along any component of which) the ease of transportation is not greatly different. Whether the potential spread effects of a road system will be realized depends, of course, on whether the road-building authorities do or do not develop a road network rather than a road axis. All too much money has been spent by less developed countries in connecting large cities by means of paved roads, and entirely too little has been allocated to building a network of roads that can help commercialize and invigorate rural landscapes, and at the same time stimulate the development of many smaller communities, thus increasing the spread effects of given amounts of investment. Roads also have a technical-financial advantage over railways. Because a railway cannot operate without a graded and ballasted roadway, or without bridges, rails, ties, switches, "back-shops," stations, marshaling yards, nor, of course, without locomotives and cars, the whole apparatus must be concurrently provided, involving an initial cost per mile that may be inordinately high in relation to the initial volume of traffic. In the case of a road, the investment may be gradually increased as the traffic grows, thus obviating the tying up of capital in a few routes with underutilized transport capacity and releasing the saved capital for other areas. In the majority of underdeveloped countries, however, the potential spread effects of road transport have been very feebly realized, while the polarizing effects of old railways are being exacerbated by the additive polarizing effects of intercity highways. As a consequence, the movement of goods, capital, people, and entrepreneurship to great cities continues, unwittingly leading to seemingly unmanageable social problems and furthering an unwanted structural dichotomy which economists have labelled a "dual economy."

Some consequences of polarized urbanization. There is a widespread belief in underdeveloped countries that poor countries are poor because they are inadequately urbanized. It is of course quite true that in "advanced countries" a much larger fraction of the population is urban than is the case in underdeveloped countries. But it does not follow that urbanization will by some automatic process necessarily lead to "development;" it is entirely conceivable that certain types of urbanization may actually arrest rather than stimulate development. More than one Asian or African country is discovering that a planless drift of workers in the prime years of their potential productiveness to sprawling, slum-cursed cities, where huge manpower reserves already exist, may mean not only a tragic misuse of human resources but an equally prodigal wastage of scarce capital by reason of unwarranted pressures on all varieties of municipal facilities. Maintenance, repair, and depreciation costs accelerate; the costs of public surveillance, sanitation, and welfare escalate at rates wholly out of proportion to the growth in the public-revenue yielding capacity of the urban economy. The presumed be-

neficence of urbanization is not very evident in Manila, Djakarta, or Calcutta!

The trouble is that so little attention has been paid by planning or executive governmental authorities to the possibilities of controlling, directing, and manipulating the movement of population in terms of some visualized pattern of central-place urbanization. In most developing countries the process, wittingly or unwittingly, has actually been the very opposite. On the presumption that industrialization is good for all countries and particularly beneficial to economies with endemic underemployment, far-reaching programs of planned investment in selected "key" industries have been launched. A very large number of the resulting new enterprises tend to be established in or near existing large cities to obtain location advantages, particularly from transport and external economies. But in computing these locational advantages virtually no consideration has been given to the total macroeconomic costs that may be involved. Thus an enterprise need not consider as a cost the probability that it may soon contribute to an overloading of a city's housing, its sewage system, or its capacity to generate electric power. The new firms are not asked to bear any special responsibility for the rapidly rising costs of fire protection, police, sanitation, public health, and water supply; they may instead be exempted from tax liability for a number of years.

The social and economic incidence of India's population drift to large cities has been described and partially measured in Bulsara's study of nine large municipal areas, chosen as samples of regional urbanization, together with Bombay as an illustration of the even more acute problems of great cities. All ten cities expanded very rapidly during the first half of the twentieth century, some doubling, others tripling. After independence the townward drift was complicated by a massive refugee problem, and the crush of urbanization quickened so much that in the single decade 1951-61 Bombay's population increased 46 percent and that of the nine provincial cities grew by 38 percent, while India's overall population growth was about 15 percent. With what consequences? The city population becomes steadily more masculine, thereby altering the nation's workforce composition, directly in cities, inversely in rural areas. Moreover, a disproportionate fraction of the city-dwelling males are in the 16-45 age bracket—not a cause for complaint if these most productive years are well utilized, but, unfortunately, this was not what the Indian investigators found. The percentage of unemployment that fell on the recent arrivals has been shockingly high, ranging from a low of 33.4 percent (Surat) to a high of 52.8 percent (Gorakhpur). Unemployment is not a brief or transient experience; 73.7 percent of men out of work in Lucknow had been unemployed for more than a year, as had 70 percent in Surat, 46.2 percent in Gorakhpur, and 38.5 percent in Kanpur. The wastage of the productive power of these

men in their prime of life must be considered a serious national loss attributable to a planless cityward drift. The in-migrants who suffer so disproportionately from unemployment have a higher literacy rate than the (more fully employed) town dwellers. Moreover, the incidence of unemployment is higher among the educated and highest among migrants who hold secondary school certificates. Since the majority of migrants have come from rural areas, the townward drift acts as a "brain-drain," luring from farming areas and small towns the talents and the energy of the young people that are so urgently needed in rural areas and so ineffectually utilized in the large cities.

One distressing consequence of the rush to cities in India and in other Asian cities is the inadequacy of housing. The Bulsara report revealed that single-room tenements sheltered 77 percent of the population of Bombay and 67.3 percent in Kanpur. Smaller cities were not so crowded: Surat had 33 percent in single-room tenements, Hubli only 27.4 percent. Seven to ten persons to a room was not an atypical finding. Even more indicative of the hardships that result from overurbanization is the inadequacy of facilities for cleanliness and for the maintenance of public health. The evidence rather consistently shows that the larger the city, the worse the conditions. In Hubli (population 171,326) only 13 percent of houses were without bathing facilities, whereas in Baroda (population 298,398) the figure was 65.8 percent, and in Lucknow (population 594,440) 86.4 percent. Or, taking another test, in Hyderabad-Secunderabad (population 1,251,159) only 43 percent of families were without independent kitchen facilities, whereas in Bombay (population 4,152,056) the corresponding figure was 71.4 percent. Only in the provision of electric energy for lighting did the great cities show a better record than the smaller ones, but this is a rather special situation that has political overtones.

In practically all less developed countries the trend is the same. Relatively fewer migrants now go short distances to nearby towns and relatively more move longer distances to metropolitan centers. Some undoubtedly earn more in cities than they did before and have more variety in their pattern of consumption, but whether they have achieved a better, fuller, more useful life is by no means certain. There is indisputable evidence of physical, mental, and moral deterioration. Worst of all, the unchanneled drift of people to the relatively few cities has frustrated and counteracted any prospects of a diffused type of orderly urbanization whereby a vitalization of rural landscapes could be set in motion by the location of new industrial establishments, processing plants, and service industries at carefully selected growth points. It has allowed the nations that most urgently need an organically integrated regional development to weaken the links between town and country and allow an unplanned dual economy to emerge.

This urban-rural dualism has its counterpart on a larger spatial scale in the contrast between the more advanced and progressive regions of a country, and the more backward, stagnant regions. Of course, economic development is never a uniform process. Even in advanced and mature countries there are persistent backwaters such as Appalachia in the United States, or the Mezzogiorno in Italy. In developing countries preferential policy efforts to homogenize the regional rates of economic development have usually failed, despite disproportionate assistance given to the laggard or disadvantaged regions. Some regions may be poor in resources, or their people may suffer from endemic diseases which reduce their productive capacity. Other associated causes are: low rates of capital formation, inadequate education or training of the work force, inefficient scales of production. All these factors, by compounding their effects, eventuate in low productivity. Regional growth differentials must therefore be expected; the policy problem is not how to eliminate these differences, since that is probably impossible, but how to reduce them or how to prevent them from becoming wider.

Spatial Reconstruction: Some Policy Aspects

With the best of intentions, all too many developing countries have embarked on investment policies that are widening rather than narrowing regional differences. No one will quarrel with the thesis that the main object of planning in underdeveloped countries should be to increase the total amount of investment aimed at raising the productive powers of the country. But it is not enough to allocate the intended investment between economic sectors or to distribute the funds between new plants, infrastructure, housing, public health, and education. It is fully as necessary to select the geographical places where the investments are to be made in accordance with appropriate criteria, and these critically important decisions have been generally ignored by economists and planners, and have too frequently been left to logrolling politicians.

According to widely accepted economic reasoning, competition in the more developed areas of a country leads to falling returns on investments; these decreasing yields should then tempt investors and entrepreneurs to redirect their funds to new spatial frontiers in the less developed areas. It could be argued that, if nature were left to take its course, inexperienced governments in less developed countries would not need to embark on uncharted experiments with "induced" development. In time, presumably, the investment contours will widen until there will be equalization of rates of return on capital and on managerial compensation in all parts of the country. No intervention is needed because the true productive potentials of the peripheries will presently be discovered by the enterprise system. What is needed is patience and faith! But, as John Friedmann puts

it: "a major difficulty with the equilibrium model," which posits that capital will spontaneously flow from lower to higher productivity areas and thereby animate development in spatial backwaters, is simply "that historical evidence does not support it."

The opposing school, with which I ally myself, insists that disequilibrium is built into transitional societies from the start. Historical evidence shows that after almost two centuries of industrialization the presumed spatial equalization has occurred neither in Western Europe nor in the United States; witness the endemic poverty in the Borinage region of Belgium, in Appalachia, South Wales, and elsewhere. Market forces have not generated a demand for the services of the underemployed labor even though wage rates have been lower in these pockets of poverty. Capital has not flowed to the low-wage areas, nor have underpaid workers migrated to higher-wage locations in sufficient numbers and thereby equalized wage rates in centers and peripheries. Since there has been incomplete regional convergence of factor compensation in "mature," completely commercialized, and industrialized countries, one can hardly expect neat equilibria to emerge in underdeveloped countries.

Reasons for persistent disequilibrium. The diminishing returns for investments in metropolitan areas, forecast by the equilibrium theorists, rather consistently seem to be offset by growing external economies or are neutralized by technological or managerial innovations; consequently, since profits can continue to be made by investing in "centers," strong incentives to seek investment opportunities in peripheries are lacking. Moreover, because investors and entrepreneurs are familiar with business opportunities in large metropolitan centers, and since data relevant to new ventures can be readily assembled there, it is always much easier to establish new enterprises (or expand old ones) in center locations than to launch new projects in smaller, less familiar locations in the peripheries. In addition, because a center is almost always the high citadel of finance, education, research, planning, and control services, it will have many advantages over simpler hinterland towns and small cities. Its population will be more skilled, varied, versatile, and innovative. As more industries seeking "urbanization economies" congregate in centers, it may well be that only those industries whose input requirements indicate a location near weight-losing materials will tend to be found in peripheries. In contrast to all these cumulative advantages of the center one usually finds in the peripheries overpopulation and underemployment leading to out-migration, which leeches rural communities of their ablest young persons; lack of capital, since much of the available savings tends to find investment outlets in centers; and relatively inexperienced and cautious entrepreneurship. For all these reasons the trend toward income convergence (for in halting ways there is such a trend)

is very slow, one that is often arrested by technological and managerial innovations before it has produced much change. The centers of "core regions" of developing countries are much more likely to develop or borrow technological innovations, particularly when they will be favored by foreign investors and promoters.

This trend toward economic polarity, which has been documented in so many contexts that its pervasiveness cannot be denied, indicates that planning will be imperative if the great interior spaces of the "third world" are to be modernized. The question no longer is whether to plan but rather how to plan, what to plan, and with what spatial goals and targets. Unless underdeveloped countries are prepared to adopt the Soviet type of spatial policies, which envisage few cities and are content with virtually townless agrarian landscapes—and with rural development the weakest element in Soviet growth, this experience is not encouraging—I would urge that the first objective of regional planning must be a systematic projection for the progressive development and numerical increase of properly dispersed agro-urban central places. The void between the ubiquitous villages and parasitic great cities must be bridged. Obviously, a whole hierarchy of central places cannot be preplanned or quickly built. What can be done, however, is to coagulate programmed investments, both private and public, into new, well-located capital clusters that can become nuclei around which the "powerful forces of spontaneity" can gradually begin to exert their influence.

Creating an investment climate in rural areas. If a town-building program is to be launched, and if, once started, its momentum is to be maintained, a number of planning steps must be systematically taken in each region whose transformation is contemplated. Because there are in every landscape some well-located villages, strategic road crossings, important river-road junctures, or places where the population exhibits better than average energy and drive, such locations can become particularly promising growth points. In these, certain already programmed investments can be coagulated into what I call "investment clusters." Here regulated agricultural markets can experimentally be established to see whether they will create a "field of attraction" to farmers. If they do, then a road-building or road-improving program and a selective electrification expansion can be undertaken to stimulate some measure of local subpolarization. The process might well be quickened if appropriate coordinating and capital-assembling institutions are established, competent to guide and assist the whole town-building program. But these several steps in the planning chain are all dependent on the success with which an investment climate can, more or less artificially, be produced so that private investors will voluntarily join their capital with public-sector capital inputs, thereby setting in motion a cumulative and multiplying type of capital formation. It is quite feasible to

create such an investment climate, one that can attract capital from outside a local community and by that example induce wary local propertied people to venture capital in a development program.

Regional investment policy. Assuming that all the regions of an underdeveloped country stand in need of modernization, the question arises as to where to begin. Should planners accord both advisory and fiscal priority to the most backward regions, or should efforts be first directed to areas where returns will be larger, earlier, and more probable? The latter course would seem best if the swiftest possible increase in national output is the chief objective. But short-run wisdom may be long-run folly. If growth points are sought only in the more "progressive" regions, then regional differences in productivity, in marketed fractions of farm output, in incomes, standards of living, and education may widen further. This would not only bring more misery and inefficiency in the 'most backward' regions but would inhibit these often heavily-populated areas from becoming reciprocal trading partners with the more favored regions. Further, the choice is not simply one between regions. A decision has to be made whether a "saturation" technique will be followed within a chosen area, with enough growth points selected so that something similar to a classical landscape of market hexagons might result; or, conversely, whether growth points should be dispersed at random on the assumption that wherever they are they are worthy of development as individual sites and their improvement will benefit not only a particular locality but, in some way, the national economy as well. The latter procedure might make it possible for the more backward areas to share from the start in a town-building program (provided they have any eligible growth points) rather than be forced to wait until the progressive regions have first been favored.

Because every development project has political implications, it is always difficult for decision makers to follow any neat economic prescriptions. But favoritism for the politically vocal, most backward areas may lead to the placement of industrial estates or other sunk-cost investments in wrong places, just as the artificial establishment of market stalls or produce warehouses may involve a waste of resources if they are not adequately utilized because hinterland farm techniques are too primitive, the fragmentation of land too limiting to permit the production of marketable surpluses, or the cultural constraints so stultifying that prices have no luring effect on production. And yet the poorer, less promising areas cannot be ignored or neglected. The same troublesome issue that always arises concerning the allocation of resources between the more backward and the less backward areas will necessarily complicate the planners' tasks when they try to select growth points. Perhaps the best compromise would be to "saturate" portions of one

or more of the better regions, while randomly chosen growth points are used as "pilot projects" in the more backward areas. The decision is essentially political, and all the economist can do is to estimate the relative cost-benefit consequences of alternative action programs. But he will be remiss if he does not point out that the selection of growth points is not something that can be dealt with on a crude patronage basis; there are rigorous criteria that must be applied if the waste of resources is to be avoided.

As an illustration of what can happen when spatial aspects of investment are not carefully considered, the Indian experience with industrial estates is instructive. Because industrial estates had proved to be useful means for establishing new manufacturing enterprises in Canada, Ireland, Puerto Rico, and elsewhere, the Government of India, beginning in 1955, decided to "program" industrial estates in their development plans. Provision was made for 10 estates in the First Plan (1951-56), for 87 in the Second Plan (1956-61), and for 300 in the Third Plan (1961-66). The initial decisions were to locate most of the industrial estates near large cities; a few estates were located near medium-sized cities, but no clear and consistent policy of spatial development had been formulated. When the political representatives of smaller communities protested loud and strong against the way in which large cities had grabbed a lion's share of the Second Plan funds, an even more impulsive decision was made to locate a majority of Third Plan estates in rural communities, many of which were ill-equipped in terms of transport, public utilities, manpower, and entrepreneurship to utilize the "sunk costs" so carelessly allocated. The consequence was that a hasty attempt to offset the trend toward economic dualism largely misfired and resulted in a further waste of resources that capital-poor India could ill afford. The trend toward economic polarization in great cities cannot be so easily averted by a random scattering of investment throughout an economic landscape, with locational decisions made by politicians wholly unprepared or unwilling to engage in the kind of studies needed for wise spatial investment choices. This is a really complex task that calls for technical judgment involving geographic, economic, sociological, and other scientific aspects of prospective "growth points."

Choosing growth points. In selecting rural sites that have better than average prospects of becoming future agro-urban communities, two locational considerations arise. What should be the characteristics of the region in which such a growth point will be sought, and, secondly, what special features should a particular site within a region possess? Since many geographic, agronomic, and ethnographic factors will influence the choice of both region and site, it is not easy to isolate general determinants, but there are some. The growth potential of any chosen site will perforce depend on the productive ca-

pacity of the region in which it is located, on its capacity to assemble or process "critical" crops that are important not only to the local area but to the entire economy. The first criterion for evaluating a region will therefore be its present crop-producing performance; the second will be its potential future productive capacities. This methodology can be very useful, but it does have some limitations. It does not, for example, come to grips with the most backward-least backward syndrome, and it cannot by reason of its indifference to where growth points are focused, estimate the possible cumulative effect of a "saturation" approach to town building in a chosen area. For if a saturation method seems worth trying, and a strong case can be made for it, then in all likelihood some sites will have to be included that will have lesser potential than sites in other regions that may have to be excluded.

The saturation approach is based on the expectation that the whole will be greater than the sum of its parts. The assumption is that the deliberate creation of a polka-dot pattern of rural growth centers in a chosen area will be more likely to result in a regional urban hierarchy than would be the case if rural growth centers were dispersed at random, and that such a network of rural growth centers will give greater scope and opportunity for what Losch has called the "powerful forces of spontaneity." Moreover, since one of the first objectives of a rural growth center program is to increase the degree of areal commercialization, regional concentration of such centers might make it possible to reduce the unit costs of transport (by increasing the volume shipped) to the advantage of both rural producers and urban consumers. The thrust of the emergent centers should be toward the progressive development of places where trade, service, and some appropriate manufacturing facilities will be within access of agricultural hinterlands, thereby providing not only markets for farm products but employment for farm-born young people. Employment aspects of town-centering development policy may also justify some experimentation with saturation on the presumption that there will be more variety in the mercantile, service, and manufacturing activities in a dozen closely nested market-town areas than there could be in any single rural growth center.

Of the general determinants for the selection of growth centers, their regional land capacity for future expansion of "critical" crops is clearly the most important. Ideally, this forecast would involve estimating for each crop the potential capacity of the region and measuring the optimal regional productivity by "crop trade-offs," which would reveal the possible gains and the probable opportunity costs. Regional profiles of resources ought to be made, together with projections of what these resources might reasonably be expected to produce under a feasible degree of technical guidance. Once these regional potentials are estimated, the search for best

sites within regions can begin. Market contribution maps of the recent annual agricultural outputs could be prepared showing the differential capacity of small areas within a region to deliver market surpluses to sales points. It should not be forgotten, however, that social criteria are sometimes as important as physical factors. Even deep rich soil, suitable terrain, and adequate rainfall will not suffice unless there is "evidence of a rising civic spirit," of ambition and drive on the part of a majority of the people, a willingness to work, save, and invest. Much will depend on the quality of leadership a community can muster and on the ability of leaders to inspire confidence and enthusiasm of their fellow-citizens.

Coagulating investments into clusters. The site for a rural growth center will ordinarily be found in an existing village or small town where some marketing, merchandising, and service facilities already exist. The planning task is then to devise ways and means for improving these facilities, adding new capital installations, providing minimally necessary public services, and establishing such educational, health, and other institutions as will be necessary to make the center a place that will attract buyers and sellers from a widening hinterland. An "investment cluster" is a grouping in one place of business enterprises that can, by the communicative power of its proffered goods and services, stimulate greater agricultural production, improve the quality of farm produce, and induce farmers to augment their marketable surpluses. Unlike a cluster of similar factories (shoe factories in Brockton, Massachusetts, or cotton textile mills in Ahmedabad, India) an investment cluster in a rural growth center will consist of varied and different enterprises.

The advantages of agglomeration are real and fairly predictable. As the number of mercantile, manufacturing, and service industries that coexist in the same locality increase, there is a very strong probability that total demand for all the several products and services will expand because more buyers will be attracted by the prospect of wider choice. Moreover, since a cluster of enterprises attracts more young workers than a single store or workshop can do, and since varied types of businesses will involve different training and skills, a work force will presently come into being that will be versatile and adaptable to a changing set of tasks and responsibilities. The result will normally be greater productivity, which can lead to high wages and lower prices concurrently. A clustering of workshops or small manufacturing plants will also lead to the emergence of repair and maintenance facilities as well as financial institutions that can provide short-term and intermediate credit accommodation. All these economies, generally called "external economies" since they are not the result of any single firm's managerial decisions, can emerge in varied degrees as investment clusters are formed. As more enterprises congregate in a central place, the total demand for

water, electricity, and other utilities will grow, permitting better scale economies in the production of such services and reducing the unit costs to the benefit of all users. This would be essentially an advantage of "numbers;" in contrast, the advantages of "association" are largely on the demand side. The production of a variety of products at a spatial node will attract buyers because of the sheer convenience of being able to purchase a range of commodities in a single central place; furthermore, there is another quite different benefit which a cluster of different enterprises can confer on a community. Because the types of business—mercantile, manufacturing, processing, service—are dissimilar, the probability is that their seasonal and cyclical variations will not coincide; hence a community with a cluster of dissimilar enterprises will have the likelihood of greater stability in output and employment. Thus an industrial estate with some small industries operating continuously can be a stabilizing counterpoise to a highly seasonal cannery, rice-hulling mill, or slaughterhouse.

Once astute and careful planners have chosen a site for a rural growth center, the problem is how to materialize these potential advantages. Obviously, an underdeveloped country cannot patiently wait for the "powerful forces of spontaneity" to set this process in motion, since the unpleasant truth is that these forces have not been "powerful" enough in the past, and unless an investment stimulus is provided by some "change agent," they will not be any more powerful in the future. The operational task of the planners, whoever they may be—they need not necessarily be bureaucrats of some central government ministry—the really critical responsibility for the planners is to find the needed "change agents." I say "find" because the change agents may be local entrepreneurs who can be "induced" to undertake some new venture; they may be outside investors who are "attracted" by certain concessions; or they may be certain institutions that can "extend" their activities to new growth centers. The methods and techniques will vary from country to country, from region to region. Puerto Rican planners have mainly relied on "attracting" foreign entrepreneurs, Israel has "induced" change by means of collective cooperative institutions, while Yugoslavia has "allocated" investment funds to new communes. Whatever strategy is employed, the basic task is to get a few key enterprises started at the chosen growth center sites.

This raises at once the question of whether the initial impetus must come wholly from the public sector or whether some interblending of public and private activities may be feasible. This will largely depend on the investment climate. Whatever the strategem, some adventurous innovators must be found who will assume the initial risks. Only when they have taken the first steps can one expect more conservative people to make parallel investments or establish

enterprises of an ancillary or secondary character. It should be noted that what most businessmen do is essentially imitative rather than pioneering. One of the really important functions of a development planning operation is to set this wholesome process of imitative investment into vigorous motion, for it is the imitators who will organize and operate most of the local industries, little shops, modest service activities, etc., that diversify a community, widen employment opportunities, and complement in countless ways the activities of key industries, so that the entire industrial and business service matrix becomes one of mutually reinforcing enterprises.

One of the simplest and least expensive ways to develop new rural growth centers has been strangely neglected. Each developing country has certain already programmed capital projects. India, in 1965, for example, had plans for building grain-storage facilities, plants for mixing and distributing commercial fertilizer, modern rice-processing mills, central-government warehouses, state-financed warehouses, solvent-extraction oilseed-processing plants, subdepots for the distribution of seeds, pesticides, and farm implements, village water filtration and distribution systems—all these rural improvement ventures were included in the Third Plan (1961-66) as were village-to-town roads, schools, health centers, sanitation projects, and rural electrification. The discovery I made was that no effort had been made to coordinate these improvements so that there would be investment clusters that could lead to the creation of new rural growth centers or invigorate existing small central places. Instead, each of the planning agencies deployed their installations without reference to the spatial plans of other agencies. The reason for this neglect, which is by no means merely an Indian failing, is usually twofold. The first is the narrow training of many planners, in which locational theory and geographic factors in economic development are ignored. The second reason is less innocent. What happens is that each development program becomes a "pork barrel," from which politicians dole out projects on a political basis without reference to economic consequences. Admittedly, there would be favoritism involved in allowing a single site to have not one but a half dozen programmed capital installations plus lead-in roads, electrification, a modern water system, and a health center. But the favored site might then have a really good chance of becoming an agro-urban center, which could attract private capital and, by a further diversification of shops, industries, and service industries, develop into a truly functional central place. There should therefore be no attempt to conceal the public-sector favoritism; rather, it should be flaunted in order to induce private investors to add to the marketing, processing and light manufacturing facilities.

Markets and submarkets as town-building agencies. Historically, investment clusters have grown up around agricultural markets. If

markets have been so instrumental in developing towns in the past, they can now become magnets that will attract investments in the underdeveloped countries and set in motion a town-building process that development so urgently requires. They must, however, be something better than the petty, periodic, exploitative markets that are all too characteristic of most underdeveloped areas. If they are to provide the developmental stimulus to farmers, they will need to be market places and market systems supervised by a governmental authority that is genuinely solicitious of farmers' interests (which will be difficult to insure), or they must be controlled by some organization in which producers are themselves well represented.

The history of "regulated markets" in India demonstrates how a wholesale cooperation between traders, producers, and local government can be effected with great benefit to the direct participants, to the communities in which such markets are located, and to the entire nation. In some 1,000 towns and cities, markets have been organized for one or more designated farm products in which daily sales are made through supervised auctions. Fairness to buyers and sellers, and conformity with rules, is enforced by control of the markets by elected market committees representing the interested parties—in particular the farmers, but also buyers and government. In a sample survey that I made in 1964 of 100 such regulated markets, 83 percent of the respondents asserted that market arrivals had markedly increased (estimates ranged from 25 percent to 85 percent) since the establishment of their respective regulated markets, and 55 percent of the respondents listed new processing industries that had grown up near the market yards. This survey showed an indisputable correlation between the existence of regulated markets and degrees of agrarian commercialization; other studies indicate that it was precisely those Indian states in which there were the better networks of regulated markets that have shown the highest postwar rates of agricultural growth.

The skeptic may argue that the foregoing argument merely proves that where there are towns there can be markets and that no causal connections can be inferred. Markets and agrarian commercialization, he will say, are always complementary phenomena. If towns create a demand for farm produce (whether from local consumers or from merchants who reflect demand external to the towns) markets can and will be established, but only if farmers are producing marketable surpluses. The process is reciprocal: demand might increase, and supply might be a response; or surpluses might be produced, and the available supply might attract buyers. This argument does not exclude the possibility of stimulating town growth by building markets, but it suggests that responses to stimuli (in either direction) are not automatic, and that the stimulative process may

have its limitations. In India the actual sequence was: towns, establishment of regulated markets, greater agricultural production, larger trade volume, greater areal prosperity. However, the regulated market system did not expand over the whole subcontinent of India and modernize one area after another. In some states, and in parts of others, the movement was opposed by vested interests that stood to lose monopoloid advantages by the establishment of a regulated-market system. In other states, as regulated markets grew in number there were fewer appropriate central places left in which to locate new regulated markets. Two quite different problems arise. The first is political, stemming from the opposition of entrenched groups of local merchants and usurers; only political remedies are possible, and how long it will take for effective political opposition to crystallize is a question on which I cannot offer an opinion. The second problem, which stems from the inadequacy of existing central places, calls for an entirely different solution. Once the programmed expansion of regulated markets as visualized by the Directorate of Marketing and Inspection is completed, the meliorative process will grind to a halt unless new rural growth centers are found and developed. Here, a possible answer is for established markets to organize submarkets in small towns to supply the larger markets, a process which has in fact occurred—there were about half as many regulated submarkets as markets in 1965 as in the areas I studied.

Two interrelated consequences may be expected from a well-planned program of regulated-market subyard expansion. A larger farming area will be more completely commercialized, since all producers within travel range of parent markets or subyards will have both the opportunity and the incentive to enlarge their marketed surpluses. The second effect will be to provide incentives for entrepreneurs who contribute their capital toward the gradual development of a new investment cluster. The parent market, or more particularly its market committee, can therefore be considered to be a "change-agent," since its decision to establish a subyard might very well induce both government and private investments at a chosen site. Yet in establishing a subyard all that the market committee has done is to make a locational experiment, and unsuccessful experiments can be terminated. However, remediable shortcomings of the site will soon reveal themselves. If no electric energy is available, that lack will have to be promptly corrected. Certain local public utilities—water supply, sanitary facilities—must be provided if the site is to develop into a real market center. Storage facilities will become necessary if commission men and producers are to hold their stocks for the best possible prices. But to do these things will require credit, which means that the sub-center will need a credit cooperative or a bank, probably both.

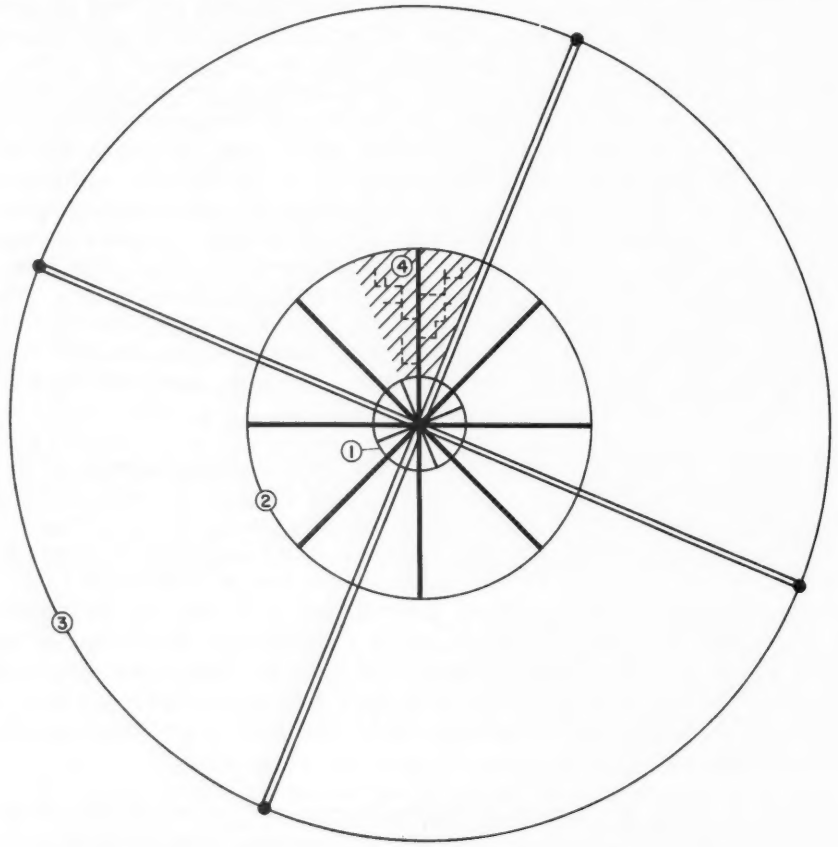
Planning subregional polarization by proper transport design. The only practicable counterpoise to the growing metropolitan polariza-

tion, which has become such a characteristic trend in all underdeveloped areas, will be the generation of countervailing centripetal forces that can converge on regional and subregional central places. To begin the requisite subpolarization effectively, and to give it momentum once it has begun, reliance will have to be placed for the most part on roads (although the local centralizing influences of electric power and other utilities ought not to be overlooked), since it is entirely feasible to develop road systems which can increase the attractive power of regional and subregional central places. Indeed, no planning task is more urgent than the designing of a transport matrix that can begin to generate resistance to the dangerous trends toward metropolitan polarity. Wilfred Owen has pointed out that "the individual city is helpless to reverse the present trends in urban settlement," even though population densities have become intolerable. Relief must therefore come from counterbalancing subpolarization, and this will largely depend on the wisdom, insight, and daring of the designers of rural road systems.

The proximate goals of regional and subregional transport planning can be perceived from an examination of Figure 2, which pictures three separable forms of transport that could, given proper design, converge on a rural growth center. The population center visualized is small, and the three circles are rough estimates of (round-trip) distances that could be traversed each day by different forms of transport if suitable roads were available. If a rural growth center is to grow, it will need at least these three types of converging transport: commuting routes, roads to bring agricultural produce to a central-place market, and highways that connect a growth center with larger urban centers.

If the rural growth center is going to become a production, processing, and service center, and if it hopes to increase the total areal employment, careful attention should be given to developing a truly functional constellation of commuting routes. If feasible, they should radiate in all directions from the center, making it possible for village-dwelling workers to travel swiftly, easily, and directly to their places of employment. For most underdeveloped countries, the means of travel for these commuters in the foreseeable future will be on foot, by bicycle, or by pedicycle. What is needed, therefore, is not expensive, wide, paved roads but a star-shaped arrangement of firm paths, paved bicycle lanes, or well-ballasted and properly bridged narrow roads. Developed countries such as Denmark, Belgium, and the Netherlands have for a long time made abundant use of such commuting routes, to the advantage of towns and cities on the one hand, farms and outlying rural hamlets on the other. There has been a signal neglect of this simple and obvious form of transport development in all too many underdeveloped countries, reflecting once again the romanticism of planners who dream

Figure 2: Road Convergence Schema for a Rural Growth Center



(1) Maximum Isochrone for Commuters
(2) Maximum Isovecture for Agricultural Produce Movements
(3) Proximate Limits for In-Bound and Out-Bound Truck Traffic
(4) Feeder Roads (sample well-serviced area)

of a system of latest-variety paved roads teeming with automobiles. A well-planned radial system of bicycle paths is a far wiser alternative because it is fiscally manageable, and because there is a reasonable chance that people in outlying villages and hamlets will be able to afford bicycles if the rural growth centers provide employment.

The spokes of the wheel representing the farm-to-market roads could be fewer than those in the commuting-path wheel. Each in-

coming hinterland-to-market road ought to have a complement of feeder roads branching out into the widening angles between the major road-system spokes. Whereas the commuting paths, lanes and roads seldom need to be much longer than 5 miles, the farm-to-market roads ought to be about 20 miles long. This estimate is made on the realistic assumption that for a long time to come draft animals will continue to supply motive power for the marketing of agricultural produce. These roads will not need to have as smooth surfaces as the shorter commuting roads, but they will need to be well-graded, diked in places where water will be high in rainy seasons, solidly ballasted, and adequately bridged.

The limited number of truck roads that ought to link an emergent rural growth center with a regional urban hierarchy will be the transport links of an agricultural community with neighboring regions, with inland industrial cities, with port towns, and through them with the world economy. These roads will need to be progressively improved as traffic increases, permitting the movement of heavier loads at greater speeds and thereby minimizing the transport cost of out-going and incoming merchandise. The thrust of these transport facilities must be inward as well as outward. The inbound transportation ought to consist of an increasing movement of agricultural inputs, raw minerals and components for the emergent small industries, as well as larger inventories for workshops and local retail outlets. Outbound transportation would move the surplus agricultural produce; this outbound volume of traffic should grow as more feeder roads are built reaching out into hitherto uncommercialized interstices. Moreover, as some measure of industrialization develops in growth centers, these truck roads will carry out manufactured goods, moving to consumers through wholesale channels.

Again the vexing problem will arise as to whether the less backward or the more backward areas should be favored in phasing the road-building and road-improving program. Fiscal limitations demand that projects such as roads will have to be locationally selective, and the proper choices of the initial sunk-cost capital inputs in the overall plan for growth centers will to a large extent determine whether the road-building program not only can continue but will steadily enlarge. A road system can become a unifying instrumentality that consolidates the productive power of an area and releases a latent social dynamism.

[Excerpted from The Organization of Space in Developing Countries. Cambridge (Mass.): Harvard University Press, 1970, pp. 1-3, 18-20, 28-29, 152-164, 171-177, 208-213, 217-230 and 234-241.

Urban Planning in Kenya

S. C. Lock

[Looking to the future, Kenya's Town Planning Department has made plans to meet the requirements of an eight-fold increase in urban population in dispersed localities over the next 30 years.

The urbanization crisis in Kenya has not yet reached the dimensions to which it has grown in countries like India; nevertheless, Kenya's population grew 3.4 percent per annum between the censuses of 1962 and 1969, a rate which, if continued, will triple the population to 30 millions within 30 years. The 1962 Census indicated that the percentage of urbanization, although increasing rapidly, was extremely low with only 23 urban centers having a population of more than 5,000 containing 8.6 percent of the population, and only 34 centers with a population of more than 2,000. However the 1969 Census revealed that urbanization was increasing at an average rate of 7.2 percent per annum and in some cases the increase is as high as 10 percent. The 1962 figure of 670,945 in towns of over 2,000 had increased to 1,096,154. This means that before the turn of this century, at this rate of urban growth, over 30 percent of the total Kenya population could be living in towns. About two thirds of the present urban population is concentrated in two cities, Nairobi and Mombasa, and if present trends continue greater Nairobi's population will be about 4.5 million by the year 2000.

A study by the Town Planning Department approaches the probable growth of Kenya's towns from the opposite angle by economists' projections of urban job formation under varying assumptions regarding the nation's overall demographic and economic growth. According

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to this study, if current targets for economic growth are achieved and population growth is reduced to 3 percent per annum, 7 3/4 million people out of a total population of 24-30 millions will be living in towns by the year 2000. Such a rate of urban growth, which is comparable to the actual experience of many countries in Asia and South America, would result in 8 times as many people living in towns by 2000 as there were in 1970. The existing urban fabric of housing, schools, shops, factories, water pipes and sewer lines will have to be multiplied eight times in the next 30 years, even if current standards are not improved. Thus, the "urban explosion" in Kenya is much closer than most people realize.

There will just not be sufficient land for all, or even most, of the grandsons of today's farmers to become farmers themselves. Preliminary studies of soil potential throughout Kenya reveal that the amount of land with surplus population absorption capacity is less than might be imagined due to low rainfall, unsuitable soil conditions and other factors, and the bulk of future generations will need non-agricultural employment. The landless and the land-poor are already making their appearance in the towns of Kenya, and they crowd into existing accommodation with relatives or build the best sort of house they can, either as squatters or on cheap land, with or without services, as close to a town as possible, but usually outside the area of the town's development control. Nairobi, with its relatively wealthy tax-base and strong administration, is absorbing the greater part of the urbanization movement in Kenya. Gross overcrowding in some quarters of the city, the existence of a large squatter community in Mathare Valley and the fact that population densities in the so-called rural areas outside the northern periphery of the city are in fact denser than some residential sectors within the city, are all signs that the provision of urban infrastructure within Nairobi is not keeping pace with the demand.

In most developed countries the responsibility for urban planning and development rests with the local authority for the particular town. The installation of much of the infrastructure, especially roads, water supply and sewers, is demanded and paid for by the citizens themselves, who realize their importance for reasons of health, amenity and convenience; and local authorities act as the coordinators of development. In Kenya, however, where the urban areas have to absorb very large numbers of people with extremely low incomes, this process is not likely to be successful. At present only Nairobi and Mombasa have their own planning staff. All other towns in Kenya utilize the services of the Government Town Planning Department in the Ministry of Lands and Settlement. The remainder of this report outlines the research and planning done by this Department.

Regional Background Research

Regional planning studies have been completed for most of the seven Provinces, based on a methodology which was evolved before work commenced. This work was done by a small team of four qualified planners and supporting staff over the last five years. The main contents of the individual provincial studies may be summarized as follows:

1. An analysis of population growth, distribution and movement related to agriculture, urban development and other factors.

2. Evidence of a maldistribution of existing social services relative to population distribution both within Provinces and between each Province.

3. A new and more rational distribution of towns of different sizes, functions and levels of importance is projected, so as to create a more balanced rural/urban relationship, providing a framework within which development agencies may carry out their policies in a manner that will produce a coordinated, logical development pattern throughout the country.

4. Proposals to prevent both the overscattering and the overconcentration of social and economic development in order to facilitate the creation of nodes of economic activity—i. e., growth points. (In one Province, for example, 35 percent of the dispensaries, 40 percent secondary schools and 100 percent tea factories are not located in any urban center, thus they do not contribute to the urbanization process.)

5. The principle of a long term growth pattern of towns and a primary road network which is effective and economic.

Each regional (Provincial) study contains basic survey information charts for each center in the Province which enables accurate and rapid assessment to be made of the content of centers; by plotting this information against the population distribution maps, one can see clearly where the gaps in services are. The studies follow up this information by including a schedule which gives all the growth points selected and the main infrastructure which must be developed in each center to adequately serve the population. Maps are included which show the detailed location of all health and higher educational establishments, the existing communication systems, and daily bus services.

Urban Planning

The Department's urban planning program is concentrated on those centers which have been selected as growth points in the Regional studies. This program covers 40 Urban Centers, 141 Rural Centers, 276 Market Centers and over 600 Local Centers. The functions of these centers within the Region may be summarized as follows:

Urban Centers (to serve a population of 100,000-150,000) are typically the administrative headquarters and main commercial centers for a whole district. They usually have a complete range of infrastructural development at the highest level, including public water, sewer and power systems and are the focus of the regional transportation pattern.

Rural Centers (to serve a population of 30,000-40,000) are typically Divisional Headquarters, having an administrative function at the level of District Officer, District Court and Police Post; a social function at the level of a health center, secondary school and community hall, although they usually lack library service. Most Rural Centers have postal service, part-time banking service, and a petrol station. They are usually located at nodal points in the local transportation pattern.

Market Centers (to serve a population of 8,000-10,000) usually have no administrative function except a Police Post. They have well developed retail and barter market facilities, a secondary school and a health center or dispensary.

Local Centers (to serve a population of 4,000). Local Centers serve a strictly local area and usually have a few shops and a small barter market, a primary school and sometimes a dispensary.

The growth points selected in the Regional studies, together with their suggested infrastructural requirements, form the basis for the detailed physical land use plans. They also serve as a guide to local development committees for the siting of new schools, health facilities and other development. A standard method of investigation and planning has been worked out, and this has led to the fairly rapid preparation of comprehensive reports and plans for several of these centers. This work generally establishes firstly, a long term growth pattern for the center as a framework for services and for very substantial increase in accordance with known population and other statistics. A short term development plan within this form is then prepared, which ensures that development is encouraged over the next five years in a pattern which does not restrict future development potential. One of the important elements within the development plan

is the zoning of a series of town residential community units on a provided site and service basis (i.e., land and basic utilities will be supplied, on which newcomers are expected to build their own houses). Bearing in mind that there already exists a strong tendency to drift towards towns in search of urban employment, this zone will cater to the anticipated excess demand which cannot be met by "normal" housing programs either for lack of finance or construction facilities or indeed the inability of the individuals to pay. It is already evident from these plans that several towns require boundary extensions involving many hundreds of acres of land, and decisions will have to be made on the question of whether such land should be brought into government ownership or left in private ownership subject to planning control.

The government is pursuing an energetic policy to attract new industries throughout the country. The rationalization and dispersal of industrial development is complicated, and there are many difficulties to be surmounted before industry can be satisfactorily decentralized from Nairobi and Mombasa. Nevertheless it is the government's intention to work towards a more even spread of development. Large towns are vigorous in their efforts to attract large industrial enterprises, and the government has set up appropriate machinery for developing small local industries. The Department's plans for individual towns offer flexibility to enable sufficient areas to be made available for considerable industrial expansion, and it is consulted at an early stage regarding the location of new industrial enterprises.

A survey of Kenya's housing needs has been completed and has provided the basis for the formulation of a realistic policy. The country is faced with an enormous urban and rural housing problem, and if shacks and slums are to be avoided large capital funds must be made available. In urban areas alone the number of new houses required annually is in the order of 10,000. Housing programs and land use plans for a five-year period have been completed for all large and medium sized towns; site and service schemes are included in these programs. A housing research unit has been established with particular reference to research into forms of construction and building materials which can compete with the low-cost traditional forms which are in many ways unsatisfactory, consisting mainly of mud and wattle construction.

[Excerpted from National Report on the Human Environment in Kenya: Case Studies. Nairobi: Republic of Kenya, Ministry of Lands and Settlement, June 1971, Part I, pp. 4-7, and 10, Part III, pp. 6-13 and 15-17.]

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